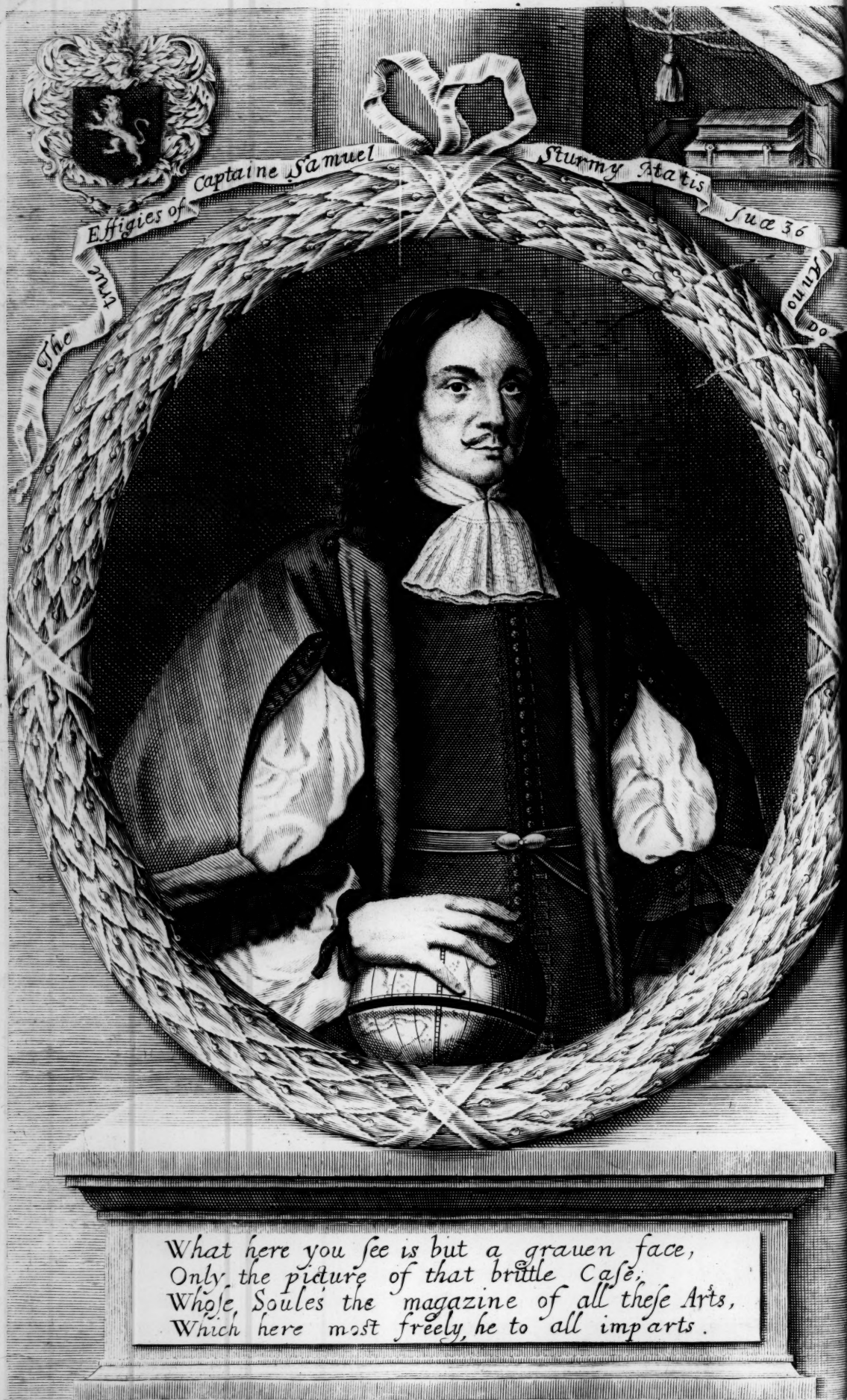
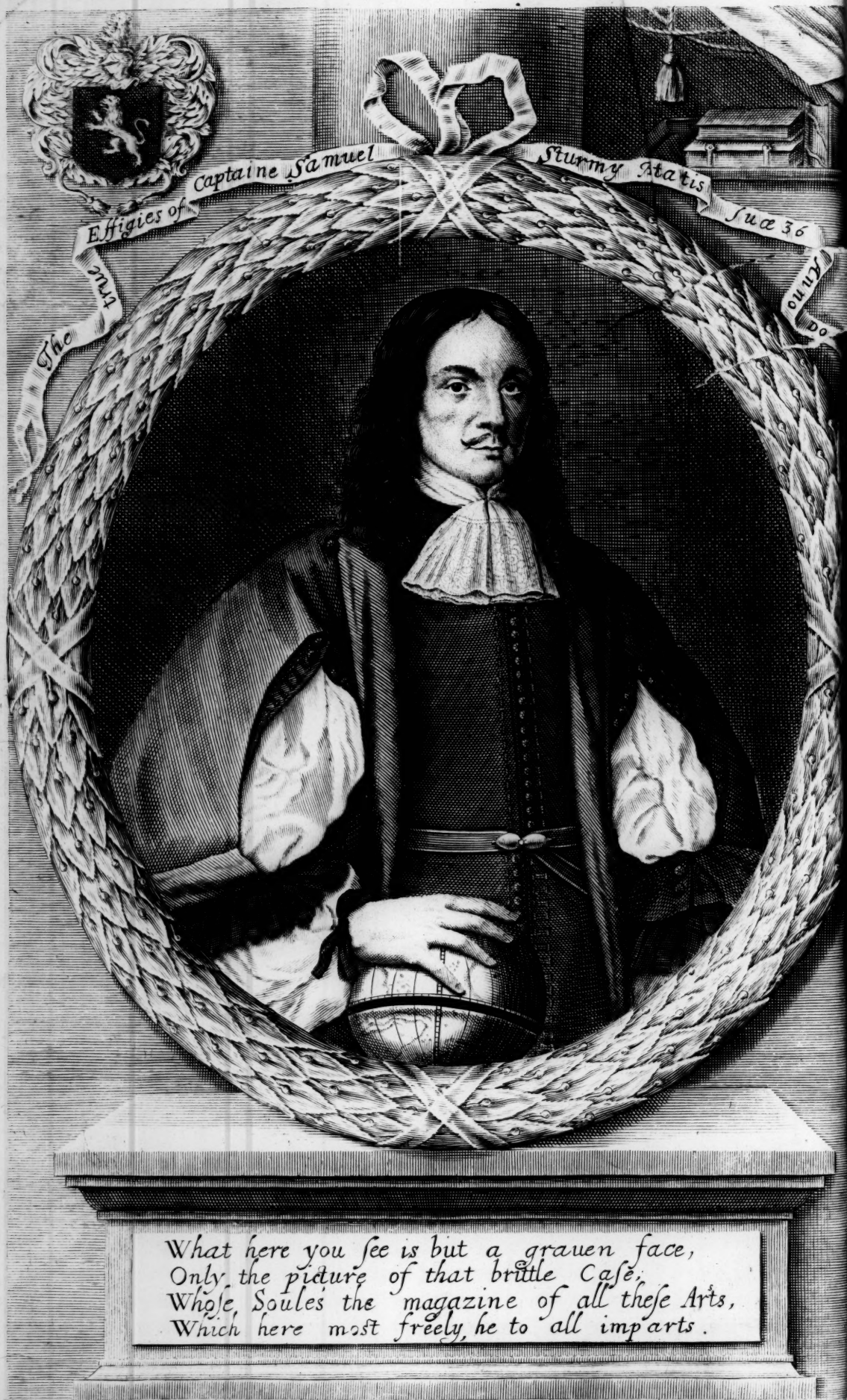

The mutable Effigies of Captaine Samuel Sturmy Ætatis suæ 36 Anno Do
What here you see is but a grauen face,
Only the picture of that brittle Case,
Whose Soules the magazine of all these Arts,
Which here most freely he to all imparts.


The mutable Effigies of Captaine Samuel Sturmy Ætatis suæ 36 Anno Do
What here you see is but a grauen face,
Only the picture of that brittle Case,
Whose Soules the magazine of all these Arts,
Which here most freely he to all imparts.


STURMYS
MATICALL AND PRACTICALL ARTS
THE
MARINERS MAGAZINE
or
Sturmys Mathematicall
and Practicall Arts.
Containing
The Description makeing & use of
the most Usefull Instruments for all Artists
and Navigators.
The Arts of Navigation at Large
a New way of Surveying of Land,
Gaging, Gunery, Astronomy, and
Dyalling, performed Geome=
trically, Instrumentally, and
by Calculation
By
Cap: Samuell Sturmy
1679
and Fortification

THE

Mariners Magazine,

STOR'D WITH THESE

MATHEMATICAL ARTS:

The Rudiments *of* NAVIGATION *and* GEOMETRY.
The Making and Use of divers MATHEMATICAL INSTRUMENTS.
The Doctrine *of* TRIANGLES, Plain *and* Spherical.
The Art *of* NAVIGATION, *by the* Plain-Chart, Mercator's-Chart, *and the* Arch *of a* Great Circle.
The Art *of* SURVEYING, GAUGING, *and* MEASURING.
GUNNERY *and* ARTIFICIAL FIRE-WORKS.
The Rudiments *of* ASTRONOMY.
The Art *of* DIALLING.

ALSO WITH

TABLES of LOGARITHMS,

AND

Tables of the *Suns Declination*; of the *Latitude* and *Longitude*, *Right Ascension*, and *Declination* of the most notable *Fixed Stars*; of the *Latitude* and *Longitude* of *Places*; of *Meridional Parts*.

WHEREUNTO ARE ANNEXED,

An *Abridgment* of the PENALTIES and FORFEITURES, by Acts of Parliament, relating to the *Customs*, and to *Navigation*.

AND,

A COMPENDIUM of FORTIFICATION.

By Capt. SAMUEL STURMY.

The SECOND EDITION, diligently Revised and carefully Corrected,
By JOHN COLSON, *Teacher of the* Mathematicks *in* London.

LONDON, Printed by ANNE GODBID, for WILLIAM FISHER, at the *Postern-Gate* near *Tower-Hill*; EDWARD THOMAS, at the *Adam* and *Eve* in *Little-Britain*; ROBERT BOULTER, at the *Turks-head* in *Cornhill*; THOMAS PASSINGER, at the *Three Bibles* on *London-Bridge*; RALPH SMITH, at the *Bible* in the *Piazza* under the *Exchange*; and RICHARD NORTHCOT, next St. *Peter's Alley* in *Cornhill*, and at the *Anchor* and *Mariner* on *Fish-Street-Hill*, 1679.


Collegium Sᵗᵉ Maria Magdalenæ
apud Oxonienſes

To the moſt Auguſt and moſt Serene

MAJESTY

OF

CHARLES II.

King of *Great-Britain*, *France*, and *Ireland*,
Defender of the Faith, *&c.*

Moſt Gracious Sovereign,



Our Majeſties Royal Grandfather King *James*, the Peace-maker, was by the Wiſeſt of His Age juſtly reputed worthy to be entituled *Great Britain's Solomon*, for His Wiſdom, Learning, and Proſperous Government.

Your Pious and Judicious Father King *Charles* the Firſt His eſteem of the more Ingenious and Politer Arts, *Sculpture*, *Picture*, and whatever elſe was Antient or Excellent, drew hither into His own Galleries and Cabinets, and other Noble Palaces of this happy Iſland, the beſt Monuments of Old *Greece*, and of Modern *Rome*: And His own Incomparable Writings will demonſtrate to ſucceeding Ages, how richly he was furniſhed with the beſt kinds of Knowledge, and with the truly Celeſtial and Divine Arts, which appeared in the whole

Course of his Life, but most of all in his last Sufferings.

And now Your Majesty hath not only an Hereditary Claim to your Ancestors Virtues and Blessings, being by God's miraculous Providence and Protection restored, and redeemed from Your Fathers Calamities; but herein You have infinitely excelled them all, and that in the main, in that you are the first Founder of a Royall Institution for the Advancement and Propagation of all Noble Arts and Beneficial Inventions: So that all the Kings in the Christian World do emulate Your Great Example, and do value themselves in nothing more, than that some of their wisest Subjects do follow and adore the Footsteps of Your *Royal Society*. And by this, that Everlasting Renown is already spread over the face of the whole Earth; it hath surrounded the Globe by Sea and Land; and we who are Borderers on the Shores, and all they who inhabit on the deep Seas, are witnesses of the perpetual Ecchoes of your Fame, with this Averment, That the better Spirits in all the Universities of *Christendom* are allured by Your Majesties Lustre to Embrace and rejoyce in this brighter Light, which can never henceforth be extinguished. And this constrains as well all Your Loyal and True-hearted Subjects, as all Intelligent and Friendly Foreiners, to offer their Applauses, Veneration, and Admiration.

But it is far above the reach of my abilities to make just report of these great Designs, and

of

of all Your Majeſties more than Heroical Accompliſhments. And yet I have a more Obliging and Perſonal Concernment: For as the Amplitude and Proſperouſneſs of Your Majeſties Dominions are chiefly maintained by Your Majeſties Countenance upon the Mathematical *Arts*, and eſpecially of *Navigation*; ſo Your Majeſty doth apparently excel all the Kings that ever were, in this noble kind of Knowledge of the *Naval Arts* and *Sciences*. And for theſe, and many other good Reaſons, I hold it my bounden duty to lay theſe Eſſays of my beſt Endeavours at Your Royal Feet; and with the proteſtation of a tryed and truſty *Sea-man*, to avouch, That not only my beſt skill in *Arts*, but my Heart and Life alſo, are entirely devoted for Your Majeſties ſervice: and all my fellow Sea-men, and all true-hearted *Engliſh-men*, do joyn in this one Voice, *God ſave King* Charles *the Second.*

Moſt Gracious Sovereign,

Your Majeſties moſt Dutiful

and moſt Obedient Subject,

SAMUEL STURMY.

To the Honourable SOCIETY of

MERCHANT-ADVENTURERS

Of the CITY of

BRISTOL.

TO THE

MASTER WARDENS and ASSISTANTS

OF THE SAID

SOCIETY.

To my Honoured Friends

Sir *Robert Cann* and Sir *Robert Yeomans*, Knights and Baronets, Sir *Humfry Hook*, Sir *Henry Creſwick*, Sir *John Knight*, and Sir *Thomas Langton*, Knights, *John Willoughby* and *John Knight* Eſquires.

Honourable Gentlemen,

Out of the great Reſpect I bear to you all of this Society, in regard from my Youth I have lived among you, and am a Burgeſs of your City, and have been Commanded, and a Commander, and have ſailed to ſeveral Parts of the World out of this Port, I cannot commit theſe Productions of my Pen to the wide Ocean of fluctuating Opinions, without the aſſurance of the Protection of ſome Honourable Patronage, as your ſelves; without the which I might haply appear miſshapen, and monſtrous as to the eye of the World, and uneaſily eſcape ſubmerſion; ſince that, as the Year conſiſting of more foul than fair Days, ſo the World in truth affords more bitter Blaſts and virulent Cenſures of Detraction, than candid, ſerene, unprejudiced Judgment. Therefore I muſt repair to you, as to Seth's *Pillar, which in deſpight of whole Torrents of Oppoſers, and Cataracts of* Zoilus *his furious Offſpring, will* (media inter prælia) *ſecure theſe my poor Labours, and perpetuate them as indelible*

as

as the Stars, or your deſerved Honours, who of your Function are the Pillars of a Country, ſupporting all manner of Trade and Commerce in the World, and like the induſtrious Bee bringing Honey to every ones Hive, in adventuring your Eſtates to ſeveral Parts of the World, for the good of many thouſands, which live and depend upon your Proſperity. I could, with many others, deſire, That this City and Society had in all reſpects the ſame Laws, and Cuſtoms in all Maritime Affairs, as the Honourable City of London: *then would much Loſs, Charge, and Damage be prevented, that many times befals your Ships and Goods; a competent Company of Sea-men, for half Pay, would attend on board at the Ships going out, and coming home, until diſcharged; and that Pay would relieve themſelves, their Wives, and Children, and fit them for the Voyage, and be great ſatisfaction to them for their attendance on your Service: for by the Rules of Charity,* The Labourer is worthy of his Hire; *and none deſerve it more than Sea-men. Then would your Sea-mens Courage be fortified, Honeſty incouraged, and deſerving Men rewarded, and the Reformers of an ill Cuſtom be had in everlaſting memory, for the Good they did in their Generation. I humbly beg pardon for this Digreſſion, and humbly deſire that you would take it into conſideration. For my part I ever did, and ſhall to the utmoſt of my poor abilities endeavour to honour this City, and will adventure my Life to ſerve this Society in any parts of the World.*

Accept therefore this Off-ſpring of ſome ſpare hours, improved more with an intent for the Publick Good, than for any Private Benefit.

I ſhall conclude this my humble Addreſs with a Temporal and Spiritual wiſh, viz. *That the Encreaſe of your Treaſures may anſwer your Hazards and Deſires, and that your Vertues and Graces may exceed your Treaſures in this Life; and in that to come, may your Glories as far tranſcend both, as Heaven doth Earth: And for this you have not only the earneſt Wiſhes, but the cordial Prayers of*

Your Honours moſt humble Servitor

to be Commanded,

SAMUEL STURMY.

Briſtol, Nov. 10. 1667.

TO THE

Courteous Reader.

MAthematical Studies have for theſe many Years been much neglected, if not contemned; yet have there been ſo many rare Inventions found, even by Men of our own Nation, that nothing now ſeems almoſt poſſible to be added more. As in other Studies, ſo we may ſay in theſe, *Nil dictum quod non dictum prius:* We at the leaſt muſt needs acknowledge, That in this we have preſented thee with nothing new, nothing that is our own. *Ex integra Græca, integram Comœdiam hodie ſum acturus*, ſaith *Terence*, that moſt excellent *Comœdian*, in his *Heauton-timorumenon*. *Tranſlation* was his Apology; *Tranſcription*, *Collection*, and *Compoſition*, ours. This only we have endeavoured, That the firſt Principles and Foundations of thoſe Studies (which were not to be known until now, but by being acquainted with many Books) might in a due method, and a perſpicuous manner, be as it were at once preſented to thy view.

Qui edifie en publique place, Faict maiſon trop haut ou trop baſſe.

Who builds i' th' way where all paſs by, Shall make his houſe too low or high.

The Matter, being Mathematical and Practical Arts of my own practice, I can the better avouch the eaſe and truth of them to all ingenious Practitioners, and unto ſuch as have as yet learned nothing but *Arithmetick*.

To that purpoſe, we have at firſt laid down ſuch Propoſitions, as all young Seamen are or ſhould be perfect in, concerning the Compaſs, and the Moon's Motion, Inſtrumentally and Arithmetically; and by it, in the ſame manner, how to know the Rules of the Ebbing and Flowing of the Sea, with the Rules of time of Flood and High-water in any Port in the World; with a Diſcourſe of the Practick Part of *Navigation*, in working of a Ship in all Caſes and Conditions of Weather at Sea, to the beſt of my Experience.

And the A B C of *Geometry*, its Definitions and Geometrical Problems, out of *Euclid* and others, as muſt be known to ſuch as would know the Nature and Menſuration of *Triangles*. Next, We have proceeded to the Deſcriptions of all the moſt uſeful Inſtruments for Artiſts and Navigators; as the *Scale of Scales*, which is a Mathematical Ruler, that reſolves all Mathematical Rules whatſoever: And we our ſelves have fitted Tables and Diagrams in that manner, as we preſume has not been done in that plainneſs, and ſo eaſie to be underſtood, by any Man before. There is the *Diagrams* and *Tables* together, both Natural and Artificial, and the *Scale*, and its Making and Uſe follows. Secondly, The Making and Uſe of the *Traverſe-Scale* of *Artificial Points* and *Quarters*; The Making of the *Quadrant* and *Index*, and their ready Uſe in *Aſtronomy* and *Navigation*; and the *Protractor*; The Projection and Uſe of the *Nocturnal*, and new Tables of the *North Star*'s Declination. And on the back-ſide are 32 of the moſt uſeful *Stars* in the Heaven for Navigators, and its Uſe;

with Tables of the *Longitude* and *Latitude*, *Right Aſcenſion* and *Declination*; The Deſcription and Uſe of the *Foreſtaff*, *Davis* his *Quadrant*; as alſo a new *Quadrant* and *Quadrat*, that I uſe my ſelf at Land and Sea; A Conſtant *Kalendar*, joyned with the Tables of the *Suns Declination*, for 32 years to come. And, Thirdly, The Nature and Quality of *Triangles*. And, Fourthly, Of Sailing by the *Plain Sea-Chart*, and the Uncertainty thereof; and of *Navigation* by *Mercator*, or Mr. *Wright*'s Projection, and by the neareſt way of Sailing by the *Globe*, or *Arch* of a *Great Circle*; with the making of the *True Sea-Chart*, Geometrically, Arithmetically, and Inſtrumentally, as the true way of keeping a Sea-Journal at Sea, very eaſie at once by *Plain*, *Mercator*, or *Great Circle* Sailing; with new Tables of *Longitude* and *Latitude* round the World, from the *Meridian* of the *Lizard*, terminating at 180. deg. *Eaſt* and *Weſt* of that *Meridian*.

The Fifth Book, The Art of *Surveying of Land* by the Sea *Azimuth* or *Amplitude Compaſs*, very eaſie and uſeful for Sea-men: The Art of *Gauging* of all ſorts of *Veſſels*, and Meaſuring of Timber, Stone, and Glaſs, and Ships, Geometrically, Inſtrumentally, and Arithmetically; and a moſt excellent *Gunners Scale*, with the eaſieſt way of *Gunnery* that hath been writ by any: For what *Nathaniel Nye* hath done by Arithmetick, by the *Square* and *Cube*, and their *Roots*, which is the hardeſt ſort of *Arithmetick*, by *Multiplication* and *Diviſion*, I have done by the *Logarithm Tables*, by *Addition* and *Subſtraction*, and likewiſe Geometrically and Inſtrumentally. The *Scale* ſhews at once, in a moment, the ready Dimenſions of twenty ſorts of moſt uſeful Ordnance, from a *Baſe* to a *Cannon-Royal*, their length, and weight of the Gun, Powder, and Shot, and Tables of weight of Shot of Lead, Iron, and Stone; with a Table of *Right Ranges* and *Point Blanks*; with a *Plain Scale* and *Dialling Scale*, *Quadrant*, and *Quadrat*, for taking of Heights and Diſtances; with a Line of *Inches* and *Numbers*, for the ready working all other Proportions of Solids, or otherwiſe; being a moſt uſeful Inſtrument for all Land and Sea *Gunners*: But moſt eſpecially I do adviſe all Sea *Gunners* to carry one of thoſe moſt uſeful Inſtruments in his Pocket, and by our Directions learn the Uſe perfectly of them. I am aſhamed to hear how ſenſleſly many Sea *Gunners* will talk of the Art, and know little or nothing therein, but only how to ſpunge, lade, and fire a Gun at Random, without any Rules of finding the Diſpart, thickneſs of the Metal in all places, and proportion any Charge of Powder thereto, and other Rules which ſhould be known. Herein how many of them are defective? And to ſupply that defect, I have taken this pains in the Art, to the end to help all ſuch as are ingenious and willing to learn: As alſo, all manner of Artificial Fire-works and Rockets, with their Figures and Fiery Arrows, Granadoes, and Pots.

The Sixth Book is the Art of *Aſtronomy*, containing the Definition of the Circles of the *Sphere*, with the manner how to reſolve all the moſt neceſſary Propoſitions thereto belonging, by a Line of *Chords* and *Sines*, and *Chords* and *Tangents*, and half *Tangents*, Geometrically and by Calculation, by the *Logarithm Tables* of *Artificial Sines* and *Tangents*: And all uſeful Aſtronomical Propoſitions appertaining to the *Firſt Motion*; and Tables for finding always the Suns true place; being all of extraordinary uſe, and made plain to the meaneſt Capacity.

Seventhly,

Seventhly, The Seventh Book is the Art of *Dialling* by the *Gnomonical Scale*, with the *Diagram* and making of the ſaid *Scales*, with Tables alſo in the Second Book deſcribed; with the *Fundamental Diagram* of all *Scales* on the *Ruler*, as alſo by Calculation, ſhewing the making of all ſorts of *Dials*, both within doors and without, upon any Wall, Cieling, or Floor, be they never ſo irregular, whereſoever the direct or reflected Beams of the Sun may come, for any *Latitude*; and how to find the true Hour of the Night by the *Moon* and *Stars*; and how to Colour, Gild, and Paint *Dials*; and how to faſten the *Gnomon* in Stone or Wood. We have inſiſted the more upon it, and by our Explanation have endeavoured to make it plain and eaſie, it being all our own Practical Arts; ſo that nothing may be wanting, which either former Ages or our own (by God's Bleſſing and their Induſtry) have afforded to us. We have to the *Artificial Canon* added out of Mr. *Wing*'s *Harmonicon Cœleſte, pag.* 263. the Rules to be taken and obſerved in uſe of Mr. *Gunter*'s *Canon* of *Artificial Sines* and *Tangents*, and Mr. *Brigs* his *Canon* of *Logarithm Numbers*, as in that Form, and in this Work, we have made uſe of his Directions in the Aſtronomical Calculation, and the Demonſtration by our own Rules; and of Mr. *Norwood*'s Advice in *Navigation*, and by Demonſtration our own (the way of our uſual practice at Sea in keeping our *Journal*) and for the *Longitude* and *Latitude* of Places, we have had the beſt Experience we could procure from the ableſt Pilots and Maſters that have been in the ſeveral Places of the World, and likewiſe of our own Obſervation of ſeveral Places in the *Weſt-Indies*, and other Parts of the World; together comparing of them with ſeveral *Tables*, formerly made and lately corrected, and fitted for a *Meridian* of our own Countrey, and the principal *Cape* of this Land, for thy eaſe; the *Lizard* being the farewel *Cape* to moſt Ships that ſail out of the *Britiſh* Seas, any way to the *South* or *Weſt*, and likewiſe the firſt Land made at their return home; and therefore it muſt needs be very uſeful for all Northern and Southern Navigators in their Voyages, with great eaſe and exactneſs.

It's nothing new, nor does it come by chance,
That Art is envy'd ſtill by Ignorance.

For the Art of *Gauging*, I have conferred with Mr. *Philip Stianred*, Mathematician and Gauger in *Briſtol*; and all the Rules that have been laid down in the following Treatiſe, are moſt exact and eaſie to the meaneſt Capacity of ſuch as are skilful in *Arithmetick*; but with a great deal of Labour, Study, Care, and Charge, in the Trial and Practice of them by our ſelf: which may be conſidered by the Ingenuous Practitioners, though much more abuſed by ignorant *Momus* and his Mates, who make it their buſineſs to ſcoff, deride, affront, and abuſe all ſuch as are Ingenious, and pretend to have any thing more than themſelves; and you ſhall know them by their railing Diſcourſe of any Ingenious Work or Artiſt. For ſuch Loiterers there is a pair of Stocks fitted in Hell by the Devil, where for their malice, abuſes, curſed railings, and villainous revilings of thoſe that Study the Honour of their Countrey to Poſterity, the harmleſs ſtudy of Virtue, and praiſe-worthy commendation of all good honeſt-minded men; I ſay, ſuch *Momuſſes* will have

their Heads in ſuch Stocks, and their Tails laſh'd by the Devils for ever, for their malice and envy, if they give it not over, and repent of it in time. But for all honeſt-minded men that love Arts and Sciences, Theorical and Practical, God doth give them His Spirit to guide them in all Lawful Arts, to the knowledge thereof, according to their deſire of Him.

Others that have either ſpent more time, or made a farther progreſs in theſe raviſhing Studies, might (if they would have taken the pains) have haply preſented thee with more in a leſs room; but the moſt of this was at the firſt collected for our private uſe, and direction of our three Brothers and Son; but now publiſhed for the good of others. Nevertheleſs, I am not ignorant, how that never any man living, in his writing, could pleaſe the phanſie of all men, neither do I expect to be the firſt. To pleaſe the envious, I cannot; for they are reſolute: To content the ſcornful, I will not attempt it: To flatter the haughty, were much folly: To diſſwade the capricious, were needleſs; and to perſwade the courteous, were unneceſſary. Let every one do as his *Genius* doth beſt diſpoſe him, take where he pleaſeth, read what he liketh, and leave what he liketh not. For my own part, I have with much diligence and induſtry waded through many ænigmatical Difficulties, and have removed and drawn back the Curtain of Darkneſs from off our *Engliſh Horizon*, in our *Mathematical and Practical Arts* following.

Laſtly, I deſire the Judicious Reader, if he chance to meet with any *Errata* (as ſome may happen in a Work of this Nature) that he would courteouſly amend them, and not with cavillation ungratefully requite my painful Labours. Haply, if this find acceptance, it may encourage me to publiſh ſome other thing, which perhaps may give thee much ſatisfaction, and be commodious to my Countrey-men of *England*. *Vale*.

Yours, and Urania's *Servant,*

St. *Georges Pill*,
10 *Novemb.*
1667.

SAMUEL STURMY.

To his Ingenious and Induſtrious Friend,

Capt. *SAMUEL STURMY.*

A double Acroſtick.

S—*uch Noble Captains Honour well deſerve,*
A—*s to their utmoſt, King and Countrey ſerve;*
M—*aking their skill and Practice freely known*
U—*nto all others who will Learning own.*
E—aſt, Weſt, North, South, *thy Compaſs will them guide,*
L—*eſt they ſhould wander with each Wind and Tide.*

S—*tir up thy Noble* Genius, *and go on;*
T—*hy Book ſhall live, when thou art dead and gon,*
U—*nto thy Glory: and proud Braggards will*
R—*epine, they could not like thee ſhew their Skill.*
M—omus *may carp, but from all honeſt Hearts*
Y—*ou'l Thanks have for your* MAGAZINE OF ARTS,

S—*ome men, when they this* MAGAZINE *ſhall ſpy,*
A—*nd note the Author, preſently will cry,*
M—*any ſuch Captains will undo the Trade:*
U—*nlock theſe Secrets, all are Captains made.*
E—*nvy thus, Devil-like, would keep men blind,*
L—*et Noble Sons of Art be free and kind.*

S—*o well ſtor'd, Captain, is thy* MAGAZINE,
T—*hat 'twill invite all ſorts: This Buſh of mine*
U—*nto thy Wine is needleſs. All men ſhall*
R—*eap Profit by thy Labour: and if all*
M—*en thus would add their Talents unto thine,*
Y—*ou'd ſoon compleat a famous* MAGAZINE.

Non nobis ſolum nati ſumus.

HENRY PHILIPPES.

To his Worthy Friend the Author,

Captain *SAMUEL STURMY*,

On his BOOK Entituled,

The MARINER'S MAGAZINE.

Sweet gentle Reader, ſearch this Magazin,
And tell me then, what thou haſt found therin:
Thou canſt not chooſe but ſay, There is ſuch ſtore
Of Mathematick Arts, *there needs no more.*
Well, to be brief, ſhould I extol thy Fame,
'Twould be in vain: Thy Book ſhall do the ſame.

PHILIP STAINRED.

To his Judicious Friend the Author,

Capt. *SAMUEL STURMY*,

ON HIS

MAGAZINE of ARTS.

READER, *Survey with an impartial Eye,*
The Care, *the* Pains, *the* Art, *the* Induſtry,
And Charge, *at which the* Author, *long, hath been,*
To Store (*with* Plenty) *this his* MAGAZEEN;
Or, rather, MART OF ARTS; *where you may buy*
(*For little Money*) INGENUITY:
And be Partaker of thoſe Arts *we call*
Sciences Liberal, MATHEMATICAL:
He having taken Pains *on th'* Deep *and* Shore,
Graſping *and* Grap'ling *to increaſe his Store;*
And after all his Toil *and* Pains (*thus ſpent*)
Gives *it his* Countrey *for an* Ornament.
Ranſack *this* CASCATE (*therefore*) *where you'l find*
Plenty *of* JEWELS *to adorn the* Mind.

Geometry. *And firſt, is repreſented to your Eye*
Selected Problems *in* GEOMETRY.

Navigation. *In* NAVIGATION *Rules it doth afford,*
Will make Men Sea-men *e're they go aboard:*
And when Embarqued *on the* Ocean *far,*
May Steer *from th'* Artick *to th'* Antartick *Star;*

And

And ſo, with Prudence, *may a* Voyage *make*
Over the Ocean's Univerſal Lake:
No Places diſtance hindring of Commerce,
Having free Traffick *through the* Univerſe.

The GEODECIAN, *in this Book, may have* Surveying.
Rules to Survey *his* Land, *and then his* Grave.

VINERIUS *now will find it no hard Task* Gauging.
To know he hath his Due, and Gauge *his* Cask.

Here MURIFRAGUS *certain Skill may gain* Gunnery.
To reach his Mark, *making no* Shot *in vain.*

And fair URANIA *leads you by the Hand,* Aſtronomy.
Deſcrying how the Spheres *to underſtand;*
Unlocking all the Hidden Treaſury,
And Secret Myſt'ries *in* ASTRONOMY.

In HOROMETRIA *Skill you may attain,* Dialling.
To trace Sol's Courſe *out on a* Dial Plain.

And the MUNITOR *hither may reſort* Fortification.
For Rules *whereby to* Fabricate *his* Fort,
To Spring *his* Myne, *and alſo* Sconces *raiſe*
Againſt his Foes, *to his Renown and Praiſe.*

And to the Trader *it will be a* Treaſure,
Yielding him Knowledge both in Weights *and* Meaſure.

With this, and ſuch like beneficial Skill,
Our Author This *his* MAGAZIN *did fill;*
And that for th' Good *and* Benefit *of thoſe*
Who honour Virtue, *and to* Vice *are Foes.*
Conſider, then, th' elaborate Pains *he took.*
And thank him as thou profit'ſt by his BOOK.

WILL. LEYBOURN.

In Praiſe of his Dear Friend the Author, for his ART,

Capt. *SAMUEL STURMY.*

OUr Artiſt here, I am ſo bold to tell ye,
Treats of no Toys, nor does he Baubles ſell ye;
Though ſuch like ſtuff indeed, it well may be,
Y' have met i' th' Mathematicks Theory:
Where he is for the Practick, *and does ſlight*
All ſuch as but Theorically write.
'Tis much and high, you'l ſay; but 'tis as ſure
Such Practick Works *for ever will endure.*
And as your fluent Naſo *dropp'd before,*
Theſe will be read where e're our Cannons rore.
Here is no trivial Traſh, or frothy Rhimes,
To Drunkards grateful at their tippling times.
Here's no Acroſticks, *nor no* Anagrams,
In Combs and Sciſſors for th' Barbarians:
Much leſs your Epigrams, *and ſuch like Toys,*
For Children fit, or at the beſt for Boys.
No novel Romance, *nor no paltry* Plays,
To wear our Time with, and miſ-ſpend our Days.
The Matter here is all ſublime and high,
That bears his Name unto the Starry Sky.
But if you neerly mark him, and his End,
You muſt confeſs, he doth them all tranſcend.

WILLIAM BERWICK, jun.

The

The AUTHOR to HIS BOOK.

GO *forth, thou ſhapeleſs* Embryon *of my Brain*
Unfaſhion'd as thou art; *expreſs the ſtrain*
And Language of thy diſcontented Sire,
Who hardly ranſom'd his poor Babe from fire,
To offer to the World and careleſs Men,
The timeleſs Fruits of his officious Pen.
Thou art no lovely darling, ſtamp'd to pleaſe
The Looks of Greatneſs; no delight to eaſe
Their melancholly Temper, who reject,
As idle toys, but what themſelves affect.
No lucky Planet darted forth his Rays,
To promiſe love unto thy Infant Days.
Thou maiſt perhaps, be Merchandiſe for Slaves,
Who ſell their Authors Wits, and buy their Graves.
Thou maiſt be cenſur'd guilty of that blame,
Which is the Midwifes fault, the Parents ſhame.
Thou maiſt be Talk for Tables, us'd for ſport
At Tavern-meetings, Paſtime for the Court.
Thou maiſt be torn by their malicious Phangs
Who ne're were taught to know a Parents Pangs.
How eas'ly can proud ignorance out-ſtare
The comlieſt Weeds thy Poverty can wear?
When all the Siſters on our Iſis *ſide*
Are oft ſworn Servants to aſpiring pride;
And our renowned Mother Athens *groans,*
To ſee her Garden ſet with Cadmus *Sons,*
Whoſe Birth is mutual Strife, whoſe Deſtiny
Is only to be born, to fight, and die.
Prometheus *is chain'd faſt, and cannot move*
To ſteal a little Fire from mighty Jove,
The people new the World, that we may ſee
Our Mother teem with a new Progeny.
And therefore with thy hapleſs Father prove
To place thy Duty, where thou findeſt love.
When thou arriv'ſt at Court, thou long maiſt ſtay
Some Friends aſſiſtance, to prepare thee way;
As in a cloudy morning I have done,
When envious Vapours ſhut me from the Sun.
When all elſe enter, ſee thou humbly ſtand
To beg a Kiſs from thy Mecanas *Hand:*
If He vouchſafe a Look to guild thy State,
Proclaime Him Noble, *thy ſelf Fortunate.*

S. S.

THE AUTHOR's COMPLAINT.

How in these days are Artists now regarded!
No, not so much as Oil or Ink rewarded.
Yet shall a Sycophant, or Rhiming Knave,
If he but Impudence and gay Clothes have,
Can harp upon some scurr'lous Jest or Tale,
(Though fifteen times told, and i'th' City stale)
Command a great Mans Ear, perhaps be able
To prefer Suits, and elbow at his Table,
Wear speaking Pockets, boast whom he doth serve;
When meriting Men may either beg or starve.
Mean time we spend our fruitless Hours in vain,
And Age of want and hunger doth complain.
It grieves us now, although too late at last,
Our time in painful Studies to have past;
And what a folly 'tis we now have found,
To cast our Seed in an unfruitful Ground;
That in time past we have laid up no store,
Which might maintain us when our Heads be hoar;
And that our shaken Vessels, torn and thin,
Can find no easie Port to harbour in.
Then, barren Arts, *seek out some other Friend;*
For I henceforth a thriving Course intend.
None will with Violets my Ashes grace,
Or strew sweet fragrant Roses in the place.
If any loves me, and intends to give,
I wish to tast his Bounty while I live.
What do I care when Fates my Thred have spun,
Though Briars and Thorns my Grave shall over-run.

Impiger extremos currit Mercator ad Indos,
Per mare pauperiem fugiens, per saxa, per ignes.

AN INDEX,

SHEWING

The CONTENTS of the SEVEN BOOKS

OF THE

MARINER'S MAGAZINE.

BOOK I.

Chap. 1. *The description of Navigation in general.* Page 1

Chap. 2. *Of what is needful first to be known in the Practick Part: And of the Compass; and how to divide it.* 3

The Moon's Age, and how to find the time of High-Water, &c. 6

Chap. 3. *The Practick Part of Navigation, in Working a Ship in all Weathers at Sea.* 13

Geometrical Definitions. 19

Geometrical Problems. 24

BOOK II.

Chap. 1. *Of Instruments in general, with Tables for the dividing of the Lines of Chords and Rumbs, as also of natural Sines, Tangents, and Secants.* 40

Chap. 2. *Of what Instruments you must be provided with before you can divide Instruments for Mathematical Uses.* 45

Chap. 3. *The Explanation of the other Part of the Diagram, being a description of the Dialling-Scale on the Mathematical Ruler.* 48

Chap. 4. *The Lines on the back-side of the Mathematical Ruler,* viz. *A Line of Numbers of Artificial Sines and Tangents, a Meridian-Line, and a Line of equal Parts or Line of Longitude, with a Scale of Reduction.* 51

Chap. 5. *A Table for the division and making of the Artificial Rumbs or Points, Halves and Quarters, on the Traverse Scale.* 56

Chap. 6. *How to make a Quadrant, which will resolve many Questions in Astronomy by the help of an Index, and also very useful in Navigation.* 58

Chap. 7. *How to make a useful Protractor.* 63

Chap. 8. *The Projection of the Nocturnal, and the Use thereof.* 64

Chap. 9. *How to use the Table of the North-Star, and thereby to find the Latitude.* 64
Chap. 10. *How to make a useful Instrument for the Stars, and by it to know when any of those Stars come to the Meridian at any time of the Year, with a Table of Longitude and Latitude, the Right Ascension and Declination of* 31 *of the most notable Fixed Stars, from* Tycho *his Tables, Rectified for the Year of our Lord* 1671. 66
Chap. 11. *Of the* Crosiers. 67
Chap. 12. *How to make the Cross-staff.* 68
Chap. 13. *How to use the Cross-staff.* 70
Chap. 14. *A Description and Use of the Quadrant.* 75
Chap. 15. *The Description and Use of a Quadrant for the taking of Altitudes of the Sun or Stars on Land or Sea, or the Altitude of Hills, Trees, Castles, or any other Object.* 78
A constant Kalendar or Almanack, shewing the Prime, Epact, Dominical-Letter, and moveable Feasts, the hour of Sun-setting each day in the Year; with exact Tables of the Suns Declination. 83

BOOK III.

Chap. 1. *Of the affection of Right-Lined Triangles.* 105
Chap. 2. *Containing the Doctrine of Right-lined Triangles, whether Right-angled or Oblique-angled; and the several Cases therein, resolved both by Tables, and also by the Lines of Artificial Numbers, Sines, and Tangents.* 107
Chap. 3. *Of Right-angled plain Triangles.* 108
Case I. *In a Right-angled plain Triangle, the Base and the Angle at the Base being given, to find the Perpendicular.* ibid.
Case II. *The Base and the Angle at the Base being given, to find the Hypothenusa.* 109
Case III. *The Hypothenusa and the Angle at the Base being given, to find the Perpendicular.* 110
Case IV. *The Hypothenusa and Angle at the Base being given, to find the Base.* ibid.
Case V. *Let the Perpendicular be the difference of Latitude* 253 *Leagues, and the Angle at* C *be* S W by W 1 deg. 45 min. Westerly, *or* 58 deg. *let it be given to find the Hypothenusa.* 111
Case VI. *The Hypothenusa or Distance sailed, the Perpendicular of Difference of Latitude given, to find the Rumb, or Angle* A B E. ibid.
Case VII. *The Hypothenusa, and the Parallel of Longitude given, to find the Rumb or Course sailed.* ibid.
Chap. 4. *Of Oblique-angled plain Triangles.* 113
Case I. *Two Angles and a Side opposite to one of them being given, to find the Side opposite to the other.* ibid.
Case II. *Two Sides and an Angle opposite to one of them being given, to find the Angle opposite unto the other.* 114
Case III. *Having two Sides and an Angle contained by them given, to find either of the other Angles.* 115

Case IV. *Two Sides and their contained Angle given, to find the third Side.* 116
Case V. *Three Sides of an Oblique Triangle being given, to find the Angles.* ibid.
Chap. 5. *Of the affection of Spherical Triangles.* 117
Chap. 6. *Containing the Doctrine of Right-angled Spherical Triangles.* 118
Chap. 7. *Containing the Doctrine of Oblique-angled Spherical Triangles.* 125

BOOK IV.

Chap. 1. *OF Sailing by the Plain Chart, and the uncertainties thereof.* 127
Questions of Sailing by the Plain Sea-Chart. 129
Chap. 2. *What must be observed by all that keep Accompt of a Ships Way; and to find the true Point of the Ship at any time, according to the Plain Chart, and of the Log-Board.* 134
Chap. 3. *A formal and exact way of setting down and perfecting a Sea-Reckoning.* 138
A Traverse-Table for every Point, Half-Point, and Quarter-Point of the Compass, to the hundredth part of a League or Mile, which gives the Difference of Latitude and Departure from the Meridian. 139
Examples and Use of the Tables, with a Journal from Lundy *to* Barbadoes *by the Plain Chart.* 143
Chap. 4. *How to correct the Accompt when the Dead Latitude differs from the Latitude by Observation.* 145
Chap. 5. *How to allow for known Currents, in estimating the Ships Course and Distance.* 147
Chap. 6. *Some difficult Questions in plain Sailing resolved.* 149
Chap. 7. *The disagreement betwixt the ordinary Sea-Chart and the Globe; and the agreement betwixt the Globe and the true Sea-Chart, made according to Mr.* Edward Wright's *Projection.* 154
A Table of Meridional Parts to the tenth part of a League, and for every ten Minutes of Latitude from the Æquinoctial, with the Use thereof in Mercator's *Sailing.* 157
Chap. 8. *How to divide a Particular Sea-Chart according to Mr.* Wright's *Projection, vulgarly called* Mercator's-Chart. 161
Chap. 9. *The Projection of the Meridian-line by Geometry; and how to make a Scale of Leagues for to measure Distances in any Latitude.* 162
Chap. 10. *Sailing by a great Circle.* 165
Chap. 11. *Containing sundry Problems of Great Circle Sailing.* 166
Chap. 12. *The Description of the Globe* in Plano *by the Mathematical Scale.* 174
Chap. 13. *To Calculate the Latitude of the Arch of a Great Circle for every fifth or tenth Degree of Longitude, from the Meridian of the greatest Obliquity.* 176
Chap. 14. *How by the Scale of Tangents to project part of the Globe in* Plano,

Plano, *whereby you may trace out the Latitudes to every Degree of Longitude, or every 5 or 10 Degrees as you please.* 177
Chap. 15. *Containing ſeveral Propoſitions of great Circle Sailing* 180
Chap. 16. *How to make the true Sea-Chart, and the Uſe therof in* Mercator's *and Great Circle Sailing, being a General Chart.* 181
Chap. 17. *How to keep a Sea-Journal.* 182
Chap. 18. *A Deſcription of the Table of the Latitude and Longitude of Places, and the Uſe thereof.* 187

BOOK. V.

Chap. 1. *TO Survey Land by the Azimuth or Amplitude Compaſs, in ſeveral Sections of Mr.* Gunters *Chain, with the Uſe thereof, and Cautions about it.* Page 3
How to meaſure a ſquare piece of Ground. 4
To meaſure a Long ſquare piece of Ground. 5
How to meaſure a Triangular piece of Ground. 6
How to meaſure a piece of Ground of four unequal Sides, called a Trapezia. ibid.
How to meaſure a piece of Ground being a perfect Circle 7
How to meaſure an Oval piece of Ground. 8
How to meaſure a piece of Ground lying in form of a Sector. ibid.
To meaſure a piece of Ground being a Segment of a Circle. 9
A piece of Ground being meaſured by a Statute Perch of 16 feet and a half, to know how many it is, being meaſured by an Iriſh Perch of 21 feet. 10
Chap. 2. *How to take the Plot of a Field at one ſtation, taken in the middle thereof, by the Compaſs.* Page 11
Chap. 3. *How to take the Plot of a Field at one ſtation, taken at any Angle thereof.* 13
Chap. 4. *How to meaſure an Irregular piece of Ground, and how to lay it down in your Field Book, and to find the Content thereof, reducing it into Triangles.* 14
Chap. 5. *How to take the height of any Iſland or Mountain in the Sea, by Example of the Author for the height of* Teneriff. 18
Chap. 6. *How to find the diſtance of a Fort or Caſtle, or the breadth of a River, by two Stations, with the Quantity of the Angle at each ſtation.* 20
Chap. 7. *How to take the diſtance of divers Places one from another, and to protract a Map thereof by the Compaſs and Plain Scale.* 22
Chap. 8. *The Art of Gauging of Veſſels by the Line of Numbers, and the Lines on the Gauging Rod, alſo by Arithmetick.* 24
The true Content of a ſolid Meaſure being known, to find the Gauge-point of the ſame Meaſure. ibid.
The Deſcription of the Gauging Rod or Staff. 24
The Deſcription of Symbols of Words for brevity in Arithmetick. ibid.
How to meaſure a Cubical Veſſel. 25
How to meaſure any Veſſel in the form of a parallel Pepedon. ibid.
How to meaſure a Cylinder Veſſel. 26
How to meaſure a Veſſel in form of a Globe. ibid.

How

The Contents.

How to measure a Barrel, Pipe, But, Puncheon, Hogshead, or small Cask. 27
How to find the Quantity of Liquor in a Cask that is part full. 29
How to measure a Brewers Tun or Mash-vat. ibid.
How to measure a Conical Vessel. 30
How to measure a Segment of a Globe or Sphere. 31
How to reduce Ale-Measure into Wine, and likewise to reduce Wine-gallons into Ale. ibid.
How to measure a Brewers Oval Tun. ibid.
Chap. 9. *Wherein is shewed, How to measure exactly all kinds of Plain Superfices, both by Arithmetick and Instrumentally.* 32
How to measure a Wall of an House in form of a long Square. ibid.
How to measure Boards, Glass, Pavement, Wainscot, and the like. 33
How to measure solid Bodies, as Timber and Stone. 34
To find how many Inches in length will make one foot of timber, being alike squared at each end. 35
How to measure a Cylinder or a Tree whose Diameters at the ends be equal. 35
How to measure a round piece of taper Timber. 36
How to measure a Pyramidal piece of Timber. 37
How to measure a Conical piece of Timber, ibid
How to find the Burden of a Ship. 34
The Use of the Line of Numbers in Reduction and the Rule of Three. 44
Chap. 10. Sect. 1. *The Art of Gunnery in a Compendious form* 39
Sect. 1. *The Qualifications eath Gunner ought to have, and his Duty and Office.* ibid.
Sect. 2. *Who were the Inventors of Gunpowder, and some Principles of Philosophy.* 40
Sect. 4, 5. *The Use of the Line of Numbers on the edge of the Scale, as likewise of the Logarithm Tables.* 43
Sect. 6. *The Geometrical finding the Diameter for the weight of any Shot assigned.* 44
Sect. 7. *How to find what Proportion is between Bullets of Iron, Lead, and Stone, by knowing the weight of any Shot of Iron, to find the weight of another Shot of Lead, Brass, or Stone of the like Diameter.* 56
Sect. 8. *How by knowing the weight of one Piece of Ordnance, to find the weight of another Piece of the same shape, and the same Metal, or any other Metal.* 46
Sect. 9. *How to make a Shot of Lead and Stone in the same Mold, of the same Diameter and weight as the Iron Shot is of.* 48
Sect. 10. *How by knowing what Quantity of Powder will load one Piece of Ordnance, to know how much will load any other Piece whatsoever.* 48
Sect. 11. *How to make the Dispart of any true boared Piece of Ordnance.* ib.
Sect. 12. *Whether the Piece be Chamber-boared.* 49
Sect. 13. *To know what Diameters every Shot must be off to fit any Piece of Ordnance.* 51
Sect. 14. *To find what Flaws, Cracks, or Honey-combes are in any Piece of Ordnance.* 51
Sect. 15. *To find whether a Piece of Ordnance be true boared or no.* ibid.
Sect. 16. *What Powder to allow for Ordnance not true boared.* 52
Sect. 17. *How Molds, Forms, and Cartrages are to be made for any sort of Ordnance.* 53

Sect.

Sect. 18. *How to make Ladles, Rammers, Sponges, for all ſorts of Ordnance.* 54
Sect. 19. *How the Carriage of a Piece ſhould be made.* ibid.
Sect. 20. *Whether the Trunnings be right placed.* 54
Sect. 21. *How much Rope will make Britching and Tackle for any Piece.* 55
Sect. 22. *What Powder is allowed for Proof, and what for Action.* ib.
Sect. 23. *The difference between common Legitimate Pieces, and Baſtard Pieces.* ibid.
Sect. 24. *How Powder is made and the ſeveral ways to know when it is decaying.* ibid.
Sect. 25, to 28. *How to make excellent good Match; and how to make Powder that it ſhall not waſt with time, and how to make good that which is bad, and how to make Powder of divers Colours.* 56, 57
Sect. 29. *Several ſorts of Salt-petre, and how to make an excellent ſort very eaſily, and with leſs Charge.* 57
Sect. 30. *How to load and fire a Piece of Ordnance like an Artiſt.* 57
Sect. 31. *The difference of ſhooting by the Metal, and by a Diſpart.* 58
Sect. 32. *How to direct to mend an ill Shot.* 59
Sect. 33. *Of ſhooting by Elevation, or Random at a Mark.* 59
Sect. 34. *How to make the Gunners Rule, to Elevate a Piece of Ordnance inſtead of the Gunners Quadrant.* 61
Sect. 35. *How to direct the Gunners Rule by the help of a Table, fitting it for any Piece from 5 to 14 foot long.* 62
Sect. 36. *How to level a Piece of Ordnance by the Gunners Rule.* 63
Sect. 37. *How to level a piece of Ordnance without the Gunners Rule.* 63
Sect. 38. *How to make a Shot at the Enemies Light in the Night.* 64
Sect. 39. *How to make a ſhot at a Company of Foot or Horſe, or a Ship under ſail.* 64
Sect. 40. *How the ſame Powder in weight ſhall carry the Shot more cloſe or ſcattering, and how a Shot that ſticketh faſt within the cavity of the Piece that cannot be driven home, may be ſhot out without any harm to the Gunner.* 64
Sect. 41. *What difference there is in ſhooting out of one Piece ſeveral Shots together.* 65
Sect. 42. *How to weigh Ships that are ſunk, or Ordnance under water; or to know what empty Cask will carry any ſort of Ordnance over a River* 65
Sect. 43. *How many Oxen, Horſes, or Men, will ſerve to draw a Piece of Ordnance.* 66

Artificial Fire-works.

A Deſcription of the Mortar-piece: How to make one of wood and Paſte-board. 67
How to fit and prepare Granadoes, for the Mortar-piece, and how to make Fucees. 68
How to make Granadoes of Canvas for the Mortar-piece; and how Granadoes are to be charged in a Mortar piece, and fired. 68
How to make Hand-granadoes, to heave by Hand. 69
How to make Fire-Arrows and Darts, like Death-Arrows heads. 69
How to make fiery Pots of Clay, and Powder Chests. 70
How to make Artificial Fire-works for Recreation and Delight. 70

How

How to make a Compoſition for Rockets of any ſize, and how to fire them. 71
How to make Serpents and Rockets that will run upon a Line, and return again: and how to make Fire-wheels. 72
How to make divers Compoſitions for Stars, and the Uſe of them. 73
How to repreſent divers ſorts of Figures in the Air with Rockets. 73
How to make Silver and Golden Rain, Fire-Lances, and Balloons for the Mortar-piece. 74
Moſt Precious Salves for Burning. 75

BOOK VI.

THE *Definitions of the Circles of the Sphere.* 81
The Projection of the Sphere in Plano, *repreſented by the* Analemna; *and by the* Stereographick Projection. 85
How to Calculate the Suns Place. 88
Probl. 2. *The Suns diſtance from the next Æquinoctial Point, and his greateſt Declination being given, to find the Declination of any Point required.* 90
Probl. 3. *Having the Suns greateſt Declination, and his diſtance from the next Æquinoctial Point, to find his Right Aſcenſion.* 92
Probl. 4. *The Elevation of the Pole and Declination of the Sun being given, to find the Aſcenſional Difference.* 93
Probl. 5. *The Suns Right Aſcenſion, and his Aſcenſional Difference being given, to find his Oblique Aſcenſion and Deſcenſion.* 93
Probl. 6. *To find the time of Sun-riſing and ſetting, with the length of the Day and Night.* 94
Probl. 7. *The Elevation of the Pole and the Declination of the Sun being given, to find his Amplitude, and by it to know the Variation,* 94
Probl. 8. *Having the Latitude of the Place and the Suns Declination, to find when the Sun comes to be due Eaſt and Weſt.* 95
Probl. 9. *The Elevation of the Pole, and the Declination of the Sun being given, to find the Suns Altitude when he comes to be due Eaſt and Weſt.* ib.
Probl. 10. *The ſame being given, to find his Altitude, at the hour of ſix.* 96
Probl. 11. *The ſame being given, to find his Azimuth at the hour of ſix.* ib.
Probl. 12. *Having the Latitude of the Place, and the Suns Declination and the time from noon being given, to find the Suns Altitude.* 97
Probl. 13. *The Suns Altitude, and the time from noon and the Declination being given, to find his Azimuth.* 99
Probl. 14. *The Latitude of the Place, and the Suns Altitude and Declination being given, to find the Suns Azimuth, and by it how to find the Variation.* 100
Probl. 15. *How to find the Altitude of the Sun by the ſhadow of a Gnomon ſet perpendicular to the Horizon, by the Scale, alſo by Calculation.* 102
Probl. 16. *Having the Latitude of the Place, the Declination of the Sun, and the Suns Altitude, to find the hour of the day.* 103
Probl. 17. *Having the Azimuth of the Sun, and his Altitude and Declination, to find the hour of the day.* 104
Probl. 18. *How to find the Right Aſcenſion of a Star, and the Declination, having the Longitude and Latitude of the Star given.* ib.

Probl. 19. *Having the Meridian Altitude of an unknown Star, and the distance thereof from a known Star, to find the Longitude and Latitude of the unknown Star.* 106
To find the Parallax of Altitude of the Sun, Moon, or Stars. 107

BOOK VII.

THE Fundamental Diagram of the Dialing Scale, and the Argument. Page 113
Chap. I. *Of the kinds of Dials.* 114
Chap. II. *Of Theorems premiſed.* ibid.
Chap. III. *How to make the Polar or Æquinoctial Dial, and how to place it.* 117
Chap. IV. *How to make the Æquinoctial Dial, or Polar Plane.* 119
Chap, V. *How to make the Eaſt or Weſt Æquinoctial Dial, Lat.* 51 d. 30 m. 121
Chap. VI. *Of the Kinds of Oblique Dials.* 122
Chap. VII. *How to make a Vertical Horizontal Dial.* 123
Chap. VIII. *A South or North Horizontal Dial commonly called an upright North or South Dial, and how to make it* 124
Chap. IX. *How to delineate a South Plane reclining* 67 deg. *Lat.* 51 deg. *and a half North.* 125
Chap. X. *How to find the Declination of a Plane.* 126
Chap. XI. *How to find the Requiſites in a Declining Horizontal Dial, commonly called an Erect Decliner.* 127
Chap. XII. *How to draw the Hour Lines in an Erect Decliner.* 129
Chap. XIII. *How to delineate an Eaſt or Weſt Reclining or Inclining Dial.* 131
Chap. XIV. *Of Declining, Reclining, or Inclining Planes.* 134
Chap. XV. *How to find the Requiſites, and how to delineate a South Reclining, or a North Inclining Decliner.* 135
Chap. XVI. *Another way to Delineate Reclining or Inclining Decliners.* 138
Chap. XVII. *How to find the Requiſits, and how to Delineate a North Declining Recliner, and a South Declining Incliner.* 139
Chap. XVIII. *How to Delineate ſuch Planes wherein the Stiles height is ſmall, not exceeding* 15 degrees. 143
Chap. XIX. *How to draw a Reflected Dial upon the Ceeling of a Room.* 144
Chap. XX. *How to make an univerſal Dial on a Globe.* 147
To Paint Dials and faſten the Stile in them. 148
The Uſe of the Table of Logarithms, and of the Artificial Sines and Tangents. 151
The Table of Artificial Sines and Tangents, alſo the Table of Logarithms, for Numbers increaſing in their natural Order, from 1 *to* 10000.
A Summary of the Lawes of the Kings Cuſtomes.
A Compendium of Fortification.

TO

TO THE

Truly Induſtrious, and Highly Deſerving of *Engliſh-men*

Captain *SAMUEL STURMY.*

On his Excellent and Elaborate Treatiſe, Entituled,

THE MARINERS MAGAZINE, &c.

IF Earth *and* Water *make one* Globe, *then he*
Muſt like a Stranger *to his* Country *be,*
That's ignorant in Navigation;
And is indeed the out-ſide *of a* Man.
For he that's truly Microcoſmical,
Owns Noah's Ships, *as well as* Adam's Fall.
The Sun *and* Man *(they ſay)* beget *a* Man:
A Menſal-Line *appends to* David's Span.
Who thinks by Retail-pow'r *his* Kind *to keep,*
And merrily expoſe the Sun *to* Sleep,
May of a Kingdom *ſoon a* Cottage *make,*
And Fences *build to't, without* Wall *or* Stake.
Nature *requires no* Miracles, *but proceeds*
In Order, by Fit Cauſes, *as ſhe needs.*
And he's the true Philoſopher, *who* views
Earth, Sea, *and* Sky; *not he on* Earth *doth* Muſe.
Can any *by* one Seaſon *underſtand*
That this our Earth, Four *diff'rent ones command?*
Or that Phyſician *reach* Anatomy,
Who knows nor Bladder *or* Emunctory?
Or can the Ableſt Theoriſt deny
That Juſt Experience's *witneſs'd by the* Eye?
Who to ſuch Sophiſtry *their* Reaſon *bow,*
Lift Fallax *up, and ſet the* Truth *below.*
In Schools, *I hold* Theorick *Knowledge good;*
I'th' World, *it leads our* Senſes *in a* Wood.
The active Soul *taking nothing upon* Truſt,
But proves its Truth: *while duller* Wights *in* Ruſt
And Sloth *conſume their* Time: *Their* empty Faith
Believes *all* true, *whatever any ſaith.*
Thus Three parts *of the* World *(in Error grown!)*
'Gainſt Practick-knowledge, *vouch* Opinion.
Had brave Columbus *worn ſo poor a* Soul,
Or hold Americus *a* Brain *ſo* Foul,
Or Noble Cabot *of that* Temper *been,*
The Indies *to this* Day *had not been* ſeen
By brisk Europeans! *Whereas now the Name*
Of worthy Columb, *gives the* Spaniards Fame;
Americus *the* Portugals; *and* Cabot *yields*
Stout Albion *Honour, all its* Glories guilds.
Who breaks the Ice *in any* Great Deſign,
(And happy Actions unto Judgment joyn)
Deſerv's to wear *their* Countries *brighter* Bays;
Who Perfects *it, merits* Immortal Praiſe.
Then thank *our painful* Author, *thus imparts*
Unto the World *his* choice *and* dear-bought Arts;
Whereby our ruder Underſtandings *may*
Gain Knowledge *in the* Mathematick *way.*
No Spot on Earth, *no part of* Sea *or* Sky,
But by this Book *Men may* learn *to* Survey.
Horologie *(an Art ſo highly priz'd,*
And by ſome Nations *almoſt* Idoliz'd!)
Is here ſo plainly *taught, that* Vulgar Men
May Dials *make, although they ſcarce know* Pen.
Now Hogen-Friar's *Skill muſt be laid by,*
It's far out-done *by th'* Author's Gunnery.
Merchants *and* Sea-men *here their* Cuſtoms *learn,*
Their Juſter Laws *from* Tyranny *diſcern.*
No Book *ſo* comprehenſive *in our Tongue*
As This. *But leſt my ruder* Lines *do* wrong,
I will retire, and leave That *to its* Fate,
Which I fore-ſee *will be* moſt Fortunate.

John Gadbury, Φιλομαθημάτικος.

A

FRIENDLY ADVERTISEMENT

TO THE

Navigators and Mariners of ENGLAND.

BRETHREN,

THE Duties of a Friend and the Properties of a flatterer do differ ſo greatly, that a Man cannot perform the Office of the one but he muſt renounce the Practice of the other; And a very Fountain it is, from whence many Miſchiefs do ſpring and overflow the wretched Life of Mankind, that the true dealing of Friends is moſt commonly unpleaſant and hateful; but the ſoothing of Flatterers is become plauſible, and much ſet by: In reſemblance they bear many times like ſhew; but in purpoſes they alwayes differ. A true Friend will ſometimes commend and praiſe divers things in his Friend; and ſo will alſo the Flatterer, in thoſe whom he followeth. The one commendeth that which in Judgment he thinketh commendable, to the end that his Friend ſhould ſtill proceed in actions worthy of Commendations; the other commendeth even thoſe things many times which in his heart he doth deteſt, to the end that he may ſooth up the Humor of the Party. A faithful Friend, what he diſallows in his Judgment of his Friend, he will be earneſt with him to ſee the fault, to the end the party may amend, and give no advantage to his Enemy: The Flatterer ſometimes, though ſeldom, will alſo diſcommend, but evermore trifling matters; fearing to offend the Party, if he ſhould touch him; ſo counterfeiting ſincere Love (the Badge only of true Friendſhip) and ſo leaveth the Party thus abuſed, to the ſcorn and reproach of the Adverſary, reaping the Commodity which he looked for, as the only end of his deſire.

I do not think that there is any Man, that either regardeth Gods glory, or eſteemeth of Humane Society, but holdeth our Art worthy to be numbred with the moſt excellent that are exerciſed among men: and therefore it is great reaſon the Practicers of it ſhould be had in greater reputation than they be now adays. Neither is there any other Art wherein God ſheweth his Divine Power ſo manifeſtly, as in ours; permitting unto us certain Rules to work by, and increaſing of them from time to time, growing ſtill onwards towards perfection, as the World doth towards its end; and yet reſerveth ſtill unto himſelf the mannaging of the whole, that when we have done what we can, according to the Skill we have already, or may have by any thing that we may learn heareafter, yet always will God make it manifeſt, That he alone is Lord and Ruler of Sea and Land; That all Storms and Tempeſts do but fulfil his will and pleaſure, who oftentimes adminiſtreth many helps, beyond all expectation, when the Art of Man utterly faileth; which is lively expreſſed in *Pſalm* 107 where is nothing omitted which is neceſſary, nor any thing affirmed but that which the continual experience of our daily dangers do proclaim to be true.

O that we that ſee his wondrous Works in the Deep, would therefore praiſe the Lord for his Mercies, and ſhew forth his Wonders before the Children of Men; that we might once learn, That the Fear of the Lord is the beginning of Wiſdom. Moſt undoubtedly then would our Art flouriſh, our Voyages proſper, and have better ſucceſs; yea, our ſelves would be more eſteemed and honoured of all men. Whereas now the profane Lives, and brutiſh behaviour of too too many of our Trade, doth ſomewhat eclipſe the Glory of the Profeſſion it ſelf. Beſides other manifold puniſhments, God ſtriketh ſome of us with the Spirit of Blindneſs, as no men living, of any Trade whatſoever, are to be found ſo ignorant as many of us are: ſo ſenſeleſs are we in our own defects,

ſo

ſo little deſirous to amend them, Yea, and ſome of us of the greateſt Skill and Practice are ſo loth to give God his due Glory, that many times labouring to ſuppreſs it, we make Shipwrack of our own Credits and Reputations, which otherwiſe of right might accrew unto us. When we have performed a long Voyage, of great difficulties, wherein many a time and oft we have been at our wits end, and know not which way in the World to turn our ſelves, God delivering us beyond our expectation, as our Conſciences can witneſs; yet when the danger is once paſt, and that home we be come, we take it as a blemiſh of our Eſtimations, and a great Impeachment to our Credit, to give God the Praiſe, and yeild him Thanks; imagining that would derogate too much from the Admiration which we ſo greedily hunt after among Men. But let me give you one example of this Ingratitude to God, on a Voyage from the *Weſt-Indies*, in the *Society* of *Topſham*, a Ship that I had command of. It pleaſed God by a violent Storm at Sea, 500 Leagues from *England*, we loſt all our Maſts, and were ſeveral times like to founder our Ship. It pleaſed God that little Proviſion we made for Sail, and the miſchievous Storm continuing, turned to our good; for the Wind was fair, but the Sea ſo dangerous and grown, that we could not Scud or Sail, but ſometimes, but in good time it brought us ſafe into the foreſaid Harbour of *Topſham*. And in our diſtreſs our Men were very mindful of Prayer, as all are; but coming to our deſired Port, I deſired them to return our gracious God Thanks, with me, for our great Deliverance: ſome were willing, but two refuſed; whereupon I told them, *That when they were next in diſtreſs, it may be God would refuſe them help or deliverance*: And ſo it fell out; for *William Witheridge* of *Kenton* in *Devonſhire* was drowned at *Bilboa* the next Voyage following, and the other was drowned at *London*. Therefore let me adviſe all, to have a care not to be ungrateful to God.

We of this Nation are too much given to admire Strangers, and contemn our own Country men.

There are many men that perform long Voyages God knoweth how, but not they themſelves; yet will ſwear and ſtare, crack and boaſt, That they have done all things according to Art; and tell a Tale to ſtrangers at home, of ſuch Gulfs and ſwift Currents, more than ever God made, to ſhadow their Ignorance, and rob God of his Praiſe: But yet for the Navigators and Mariners of *England*, I do hope and verily believe in my Conſcience, That divers of them do fear God unfeignedly, and do as much diſlike the diſſolute Courſe of the common ſort, as any men can: And I do nothing doubt, although the number of ſuch are too few in our Nation, yet are they more than any Nation in the World can ſhew beſides. However, two things are greatly wiſh'd by all our well-willers; An Increaſe in us of the true Fear of God, and a careful Diligence in us, in things belonging to our Art. Where the Fear of God is not, no Art can ſerve the turn; for that were to make of Art an Idol. And yet all thoſe that fear God, muſt take heed they do not tempt God: and therefore ought they to uſe Art, as the means that God hath ordained for their benefit, and be thankful unto him for it. *Farewel.*

Yours,

From my Houſe and Study at St. Georges, *or* Pill, *near* Briſtol. *November* 12. 1667.

SAMUEL STURMY.

THE CORRECTOR TO THE READER.

Courteous Reader,

AT the earneſt Intreaty of the Book-ſellers concerned in this Treatiſe, I unwillingly undertook the Viewing and Reforming of this Magazine, chuſing rather to erect a New Fabrick to furniſh it with a New Store, but they not conſenting, I have Repaired the Old Building, and provided the Magazine partly with Old, partly with New Store; and I have endeavoured to render the Mathematical Arts contained herein as familiar as I could, being only a Corrector not an Author.

In this Second Edition I have added the Doctrine of Spherical Triangles, alſo ſomewhat in the Aſtronomical part, and more in the Dialling, and in the whole as there was need; and ſomething I have omitted which I judged Superfluous, others I have Corrected that were Erroneous.

There are ſome Errata's of the Preſs, which we muſt pardon, the Work being troubleſome to the Printer as 'twas tedious to Me, and being not material I have omitted them; only one I muſt mention which will ſound harſh to an able Sea-man, which is in Page 16 Line 15, where after theſe words, A Lee the Helm, it ſhould have followed Let go Fore-top Bow-line, which is by his miſtake inſerted in the Line following after theſe words, Weather Braces.

To Conclude, I undertook this task for the advantage of young Students in the Mathematicks, to which I hope it will be ſerviceable, and acceptable; to whom I am an obliged Servant for their Inſtruction and Information in the Mathematicks.

JOHN COLSON.

From my Houſe in *Marſh-Yard* in *Wapping*, *Auguſt* 9th. 1678.

Ad-

Advertiſements.

IN *Marſh-Yard*, a little beyond the *Hermitage* Stairs in *Wapping*, are Taught theſe Mathematical Sciences.

Arithmetick, Geometry, Algebra, Trigonometry, Navigation, Aſtronomy, Surveying, Gauging, Dialing, Fortification, and Gunnery; the Uſe of the Globes, and other Mathematical Inſtruments, the Projection of the Sphere, and other parts of the Mathematicks,

By *JOHN COLSON.*

ALL ſorts of Mathematical Inſtruments in Wood or Braſs, are Made and Sold by *James Atkinſon*, at the *Cherry-Garden-Stairs* in *Redriff.*

THE

THE

AUTHOR

Implores Aid of

GOD'S EVERLASTING FOUNTAIN.

OH! All-ſufficient Fountain, Lord of Light,
Without whoſe gracious Aid and conſtant Sprite
No Labours proſper, howſoe're begun;
But fly like Miſts before the Morning-Sun.
O, raiſe my Thoughts, and clear my Apprehenſion;
Pour down thy Spirit on my weak Invention:
Be thou the Load-ſtar to my wandring Mind,
New rigg'd, and bound upon a new Deſign.
O, fill my Canvas with a proſperous Wind,
Grant that of thee I may Aſſiſtance find:
So bleſs my Talent with a fruitful Loan
That it at leaſt may render Two for One.

THE

The Compleat MARINER, OR NAVIGATOR.

The First Book.

CHAP. I.

The Argument or Deſcription of the Art of Navigation *in general.*

NAVIGATION of all Arts and Sciences (ſetting *Divinity* aſide) hath much reaſon to have the preheminence, it being of ſuch neceſſary and publick Concernment; and what uſe there is made of it by *Sea-man* at this preſent, as well as hath been in times paſt, All men know, to whom the Countries are beholden for their good Service, whoſe Courage hath kept *Great Britain*, *Queen* and *Regent* of the Sea, and deſerves it well, in reſpect of the Skill and Valour of her Mariners, and Goodneſs and Number of her Ships. I wiſh as long as the Sun and Moon endures, That they may maintain their Courage, and improve their Art, as they ever have, againſt all Nations that have been *England*'s Enemies; and ever may they crown their Undertakings with everlaſting Credit.

The Art of *Navigation* being ſuch, I think I may be bold to affirm without preſumption, This Art is more neceſſary for the well-being and honour of our Nation, than any other Art or Science Mathematical, which is more carefully kept in the Univerſities. Look upon *Grammar*, *Rhetorick*, and *Logick*, theſe are but Introductions to other Arts; *Muſick* is but of little uſe.

The chief Profeſſions now in the Univerſities are *Phyſick* and *Law*. Without envy be it ſpoken, we may as well live as the ancient *Romans* without Phyſicians, and as honeſt Neighbours without Lawyers, better than without skilful *Sea-men*, which are the chief *Importers* of our Wealth, and *Supporters* of our Warfare.

Beſides that, of all Mathematical Sciences and Arts profeſſed in the Univerſities, of this Art of *Navigation* is made the moſt general and profitable uſe: For what can the Scholar make of his *Geometry*, with all the nice and notional Problems thereof; or of *Aſtronomy*, with all his curious Speculations about the Motion of the Planets, without they be applied to ſome more Mechanical and Practical Arts, as *Coſmography*, *Geography*, *Surveying*, *Dyalling*, *Architecture*, *Military Employments*, which ſhall in ſome meaſure (ſufficient for the help of Mariners) be ſhewn in the following Treatiſe, wherein it will appear, That the Art of *Navigation* comprehends them all in the uſe thereof?

And thoſe that will be compleat *Sea-Artiſts*, had need to endeavour to have ſome skill and underſtanding in moſt of theſe Arts, namely, the Theorick and Practick parts, whereby they may be fully informed of the Compoſition of the *Sphere* in

general; and in particular for the *Figure*, *Number*, and *Motion* made in the Heavens by the higheſt Moveable, called *Primum Mobile*, and likewiſe of the firſt, ſecond, third, fourth, fifth, ſixth, ſeventh, eighth, and ninth Heavens. It will alſo inform them how the Elements are diſpoſed, with their quantities and ſituations, eſpecially in the Compoſition of the Sphere of the World, which is commonly underſtood to be the whole Globe of the Heavens, with all that therein is contained; which is divided into two parts, *Elementary* and *Cœleſtial*. The *Elementary* hath again four parts, *viz.* The firſt is the *Earth*, which together with the *Water*, as the ſecond, maketh a perfect Round Globe, whereupon we dwell; and therefore the Nature and Circles which are ſuppoſed to be contained in that *Sphere*, are fit to be known. The next is the *Air*, comprehending the *Earth*; and the fourth the *Fire*, which according to the opinion of Philoſophers containeth the ſpace which is between the Air and the Heavens, or Circle of the Moon. Out of theſe Elements, which are the beginning of all things that are ſubject to change, together with the warmth of the Heavens, all things do come forth, and decay, as we ſee and find upon the Earth, by the continual Change and Motion of the One into the other.

The *Cœleſtial* part (containing within the concavity thereof the *Elementary*) is tranſparent and perſpicuous, ſhining, ſevered, and free from all mutability; and is divided into eight *Spheres*, or concave Globes, which are called Heavens, whereof the greateſt doth contain the next unto it; the ſeven Inferior have in each of them but one Star or Planet only, whereof the firſt (the next to the Earth) is the Heaven of the *Moon*; The ſecond of *Mercury*; The third of *Venus*; The fourth of the *Sun*; The fifth of *Mars*; The ſixth of *Jupiter*; The ſeventh of *Saturn*; And the eighth of all the *Fixed Stars*. The number of theſe *Heavens* are known by their Courſes round about the *Poles* of the *Zodiack*. The *Moon* runneth through her Heaven by her Natural Courſe from the *Weſt* to the *Eaſt* in 27 days 8 hours; *Mercury*, *Venus*, and the *Sun*, their courſe in a year; *Mars* his courſe in two years; *Jupiter* in 12; and *Saturn* in 30 years; The Eighth Heaven, according the obſervation of *Tycho Brahe*, in 25400 years.

Theſe *Heavens* are carried all together in 24 Hours about the *Axis* of the World by virtue of the *Primum Mobile*, that is, the Firſt Moveable; by which Motion is cauſed the Day and Night, and the daily Riſing and Setting of the Cœleſtial Lights. But more of this in another place, for here I have made a digreſſion. So that no Art is more capacious; and were the Excellency well underſtood, and put in practice, as it might be (as Mr. *Philips* ſaith in the like caſe) no Employment would be more honourable and advantageous for the moſt generous Gentleman, and Learned Student, than this of *Navigation*; thus it was in eſteem in the days of Queen *Elizabeth*,

When Drake *and* Candiſh *Sayl'd the World about,*
And many Hero's *found new Countries out,*
To Britain's *Glory, and their laſting Fame;*
Were we like-minded, we might do the ſame.

The Practick part of *Navigation* is properly placed in making and uſing of Inſtruments, which is ſhewn in the Second Book. Yet there is a certain Compoſition in the Practick, more rare than all the reſt, in the compleat Sea-Artiſt; and that is the right Words and Phraſes uſed in guiding, governing, and ruling the unparallel'd Fabrick of a gallant Ship, which hath been omitted by moſt men that have writ of this Art; therefore I ſhall explain it with my Pen, becauſe I know with proper Phraſes how to perform it, not hindring any other (as they not me) to ſhew truly and lively their Skill in controlling, guiding, and working a Ship, according to all Weathers at Sea; although this be of no uſe to Sea-men, that have been all their life-time at Sea: but for Gentlemen on Shore to read for their Recreation, the Woids of Command at Sea, may be delightful unto them.

In regard all Arts and Sciences are divided into two principal parts, that is, the *Theorick* and *Practick*, and this I take upon me to demonſtrate according to my ability, which will give the moſt reaſonable men ſatisfaction; and for the unreaſonable,

unreaſonable, I care not a fig for them; for I know it to be impoſſible for any man to be a compleat Sea-man, wherein this Knowledge is wanting, they being both inſeparable Companions which always wait upon *Perfection*. I ſhall draw out the Deſcription in as ſmall a compaſs as it can be, and haſten to the moſt material Practice.

CHAP. II.

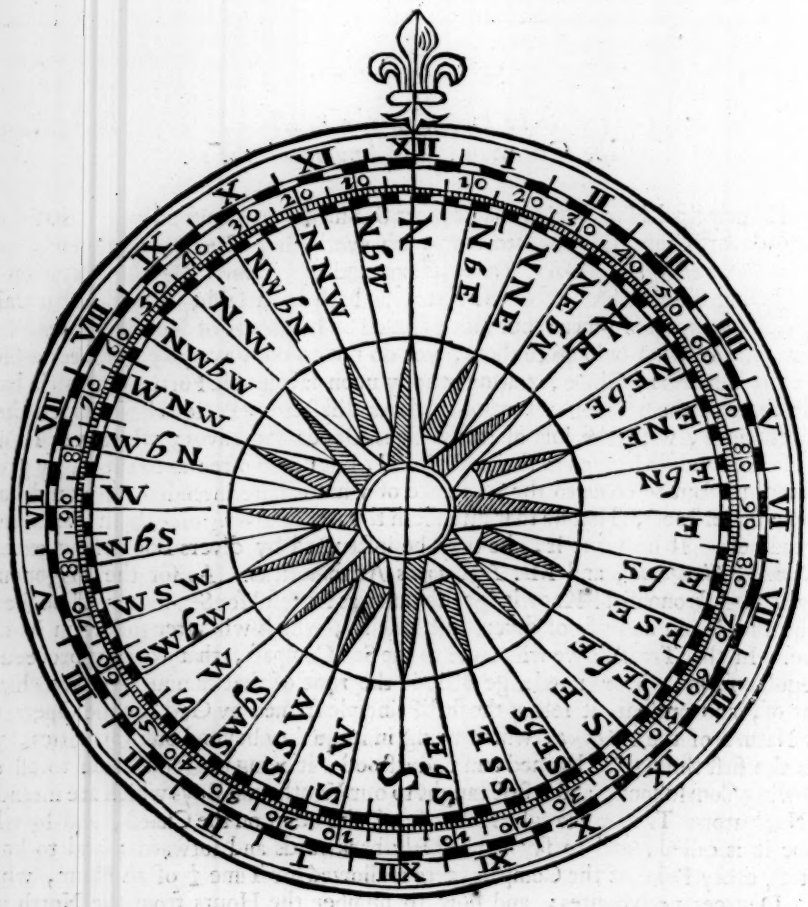
Of what is needful firſt to be known in the Practick Part of Navigation; *of the* Compaſs, *and how to divide it.*

THe principal Hand-maids that expert Sea-men are furniſhed with, that their Undertakings may be crowned with everlaſting Credit, are theſe, *viz. Arithmetick*, *Geometry*, *Trigonometry*, and *Aſtronomy*. By the operation of theſe loving Siſters, and excellent Arts, as hath been ſaid, *Navigation* is daily practiſed by expert Sea-men: but much abuſed by hundreds of ignorant Aſſes, that know nothing what belongs to them, yet do undertake Voyages, to direct a Ship upon the Terreſtrial Globe, reſting wholly upon favourable Fortune, which hath made ſome of them famous; but many times diſaſterous Periods have ended their Undertakings, with the loſs of many mens Goods and Lives; which yet I muſt confeſs have and do happen to the moſt skilful, but not ſo often as to them, by great difference. But to come to the Subſtance of what is here intended, I would have it to be underſtood, That he that intendeth the Art of *Navigation*, hath *Arithmetick* in readineſs. If he want it, he may be inſtructed by divers Books now extant, as *Record*, *Blundevill*, and Mr. *Leybourn*'s Arithmeticks. As for the Trigonometrical and Aſtronomical Knowledge, ſo much as is uſeful for Sea-men, will be ſhewn in the Projection and uſe of divers Inſtruments, which will after follow in its due place. In this Treatiſe we will come to the Sea-Compaſs, that we may proceed in a regular form: The knowledge of it is the root of that famous Art we chiefly treat of, and preſents it ſelf as the firſt Principle framed by God, in the Operation and Nature of the *Magnet*, which being in its quality beyond our capacities, yet it is the firſt thing to be learned and underſtood, it being the foundation to all the following Concluſions, and is firſt taught to our Youths and Boys which are intended for Navigators. They are taught firſt to know the Point on the Chard, and by what Name it is called, and to ſay it perfectly backwards and forwards; and to know that to every Point of the Compaſs there is allowed for Time $\frac{1}{4}$ of an Hour, which is 11 Degrees 15 Minutes; and how to number the Hours from the North and South, either Eaſtward or Weſtward, readily to anſwer as ſoon as demanded: As alſo to know how the Ship Capes; that is, to know the Point of the Compaſs that looks ſtraight forwards to the Head of the Ship: As likewiſe to know upon what Point of the Compaſs the Wind blows over; that is, if the Wind be at North, it blows over the *Flower-de-Luce* toward the South; and ſo of the reſt. So we teach them to know what Point the Sun is on: As alſo they learn to ſet the Moon on the Full and Change-days, to know the Tides by, as ſhall be ſhewed.

The Compaſs we Steer our Ships by, is only a Circle of ſome 8 inches diameter; and is divided into 32 Points, which have ſeveral denominations, as you may ſee expreſſed in the Figure. The whole Circle is divided into 360 Degrees, and 24 Hours: The Compaſs contains alſo 16 diſtinct Rhombs or Courſes; for each ſeveral Courſe hath two Points of the Compaſs, by which it is expreſſed. As for example, Where there is any place ſituated South-eaſt, in reſpect of another place, we ſay the Rhomb or Courſe that runneth betwixt them, is South-eaſt and North-weſt; or if it bear South, we call the bearing North and South; or if Weſt, we ſay Eaſt and Weſt. The Compaſs ſwings in the Boxes, the Wyers firſt well touched with a good Load-ſtone, and the Chard ſwimming well on the Pin, perpendicular in the middle of the Box; it repreſents the *Horizon*. So that when you eſpy any Iſland, Rocks, Ships, or Cape-Lands, by looking ſtraight upon the Compaſs, you ſhall know upon what Point of the Compaſs the Object beareth from you. But

we will haſte to ſhew the young Practitioners the Sea-Compaſs, with the 32 Points, expreſſed by the Letters upon each Line, and alſo how to make it, as followeth.

The COMPASS.



How to divide the Mariner's Compaſs.

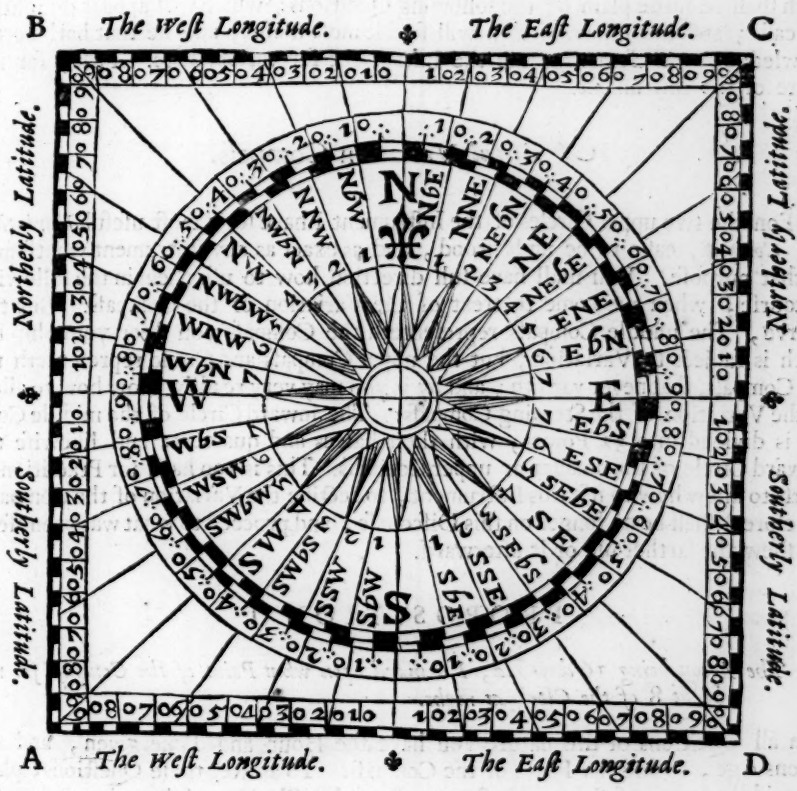
FIrſt draw a Line at pleaſure, and croſs it in the midſt with another Line at right Angles; Then in the croſſing of theſe two Lines ſet one foot of your Compaſs, and open the other to what diſtance you pleaſe, and with that diſtance draw the Circle, which by the croſs Lines of *Eaſt* and *Weſt*, *North* and *South*, are divided into four Quadrants or equal parts, each of them containing 6 hours apiece; ſet VI at *Eaſt* and VI at *Weſt*, XII at *North* and XII at *South*, ſo you have the four firſt Diviſions of your Figure: Then keeping your Compaſs at the ſame diſtance as you draw'd the Circle, ſet one foot in the croſſing of the Line and the Circle at *Eaſt* VI, with the other make two marks, at II and X. Then ſet one foot in the *Weſt* at VI, on the other ſide mark out the hours of II and X, as before; keeping the Compaſſes ſtill at the ſame diſtance, ſet one foot at *South* XII, and with the other you ſhall mark out the hours of VIII and IIII. Then ſet one foot of your Compaſſes at *North* at XII, and in the ſame manner mark out the hours of VIII and IIII. Thus the Circle is divided into 12 equal parts, and each of them contains 2 hours apiece; ſo that it will be eaſie for you to divide each of theſe into two parts; which done, you have the 24 hours. Laſtly, you may divide each hour into 4 equal parts, which will be quarters of an hour, as you may ſee in the Figures.

To

To divide a Circle into 360 equal parts, is a thing very neceſſary; for in all Queſtions in *Aſtronomy*, and in the Calculation of all *Triangles*, theſe parts are the meaſure of the Angles: ſo that in reſpect of this, every Arch is ſuppoſed to be divided into 360 equal parts or Degrees; and every Degree is ſuppoſed to be divided into 60 leſſer parts, called Minutes. To divide a Circle after this manner, draw a Line at pleaſure, and croſs it at right Angles with another Line, and draw a Circle as before. Keep your Compaſſes at the ſame diſtance, and divide the Circle from the 4 quarters into 12 equal parts, as before in the hours: then cloſing your Compaſſes, divide each of theſe into 3; ſo you have in all 36 parts. Then divide each of theſe parts into 10 other parts, as you may ſee in the middle Circle of the Figure, which are Degrees, numbred with 10, 20, 30, *&c.*

For the 32 Points of the *Compaſs*, draw the Line of *North* and *South*, and croſs it at right Angles with the Line of *Eaſt* and *Weſt*, and draw the Circle, as before; then divide each of theſe quarters into 2 parts: ſo is your Circle divided into 8 equal parts. Then cloſing your Compaſſes, you may eaſily divide theſe 8 parts into 4; divide one, and that diſtance which will divide all the reſt into equal parts, if you have done right. And ſo you have the 32 Points of the Compaſs; and ſo you may ſubdivide theſe Points into halves and quarters, as you may ſee in the Figure. So have you made the *Mariner*'s Compaſs. The uſe ſhall be ſhew'd in its place.

The Figure of the Compaſs, *and the* Traverſe Quadrat, *joyned together.*



The *Traverſe Quadrat* ſheweth the making of the *Traverſe Table*, in *Chap.* 3. Of Sayling by the plain Sea-Chart.

Of

Of the Moons *Motion, and the Ebbing and Flowing of the* Sea.

THe Practitioner in *Navigation*, is next to learn to know the certain time of the Flowing and Ebbing of the Sea, in all Ports called by Sea-men the ſhifting of Tides; which is governed by the *Moons* Motion, as it is found by experience.

Wherefore I will firſt ſhew the uſe of a ſmall Inſtrument, which is here framed, whereby the meaneſt Capacity (which is void of *Arithmetick*) ſhall be able to know the Age of the Moon, with what Flood and Ebb it maketh in all Channels, and in every Port and Creek at High-water; and alſo be able to know what a Clock it is at any time of the Night; and divers other Queſtions, only by uſing the Inſtrument, according as ſhall be directed.

I ſhall alſo ſhew you, how you may do all theſe Queſtions of the Tide Arithmetically: But firſt by your Inſtrument it muſt be projected according to the following Figure, which you may make of three pieces of Board, well planed, and exactly divided, according as you ſee it formed in the Figure. The outward Circle, being the biggeſt Board, hath 32 Points of the Compaſs: The inward Circle on the ſame Board is divided into 24 Hours, being the thickeſt Board: The ſecond Circle muſt be divided into 30 equal parts, repreſenting 30 natural days: The innermoſt Circle of the three hath an Index, and to be turned and applied to either the 30 days, containing the computation of the Moon betwixt Change and Change, or the 24 hours; as likewiſe to the Points of the Compaſs. And ſo may the other Index be applied either to Time, or the Points of the Compaſs, which ſhall be made plain by the following Queſtions; which will appear delightful and eaſie; and the illiterate man will find it moſt uſeful; and he that hath better Knowledge, will ſometime uſe the Inſtrument for variety ſake. Firſt, for the Figure of the Inſtrument.

A Uſeful Variation-Compaſs.

UPon the two upper Circles of the Inſtrument I have ſet a moſt uſeful *Variation-Compaſs*, eaſie to be underſtood, and as exact as any Inſtrument whatſoever for that purpoſe. You ſhall have full direction how to uſe them in the following Diſcourſe, when we come to treat of the Variation of the Compaſs. But this obſerve, The middle Compaſs repreſenteth the Compaſs you ſteer your Ship by, which is ſubject to Variation; but the upper Compaſs and Circle repreſenteth the true Compaſs, that never varieth; and by it you may very readily know how to allow for the Variation of the Steering-Compaſs. The inward Circle of the middle Compaſs is divided into 32 Points, with their halves and quarters; and likewiſe the outward Circle of the ſmaller or upper Compaſs. This is too hard for Practitioners at firſt to know how to uſe this Inſtrument, to rectifie the Variation of the Compaſs; therefore I ſhall be no longer on this Diſcourſe, and proceed to what was promiſed, and ſhew the farther uſe of it afterward.

PROPOSITION I.

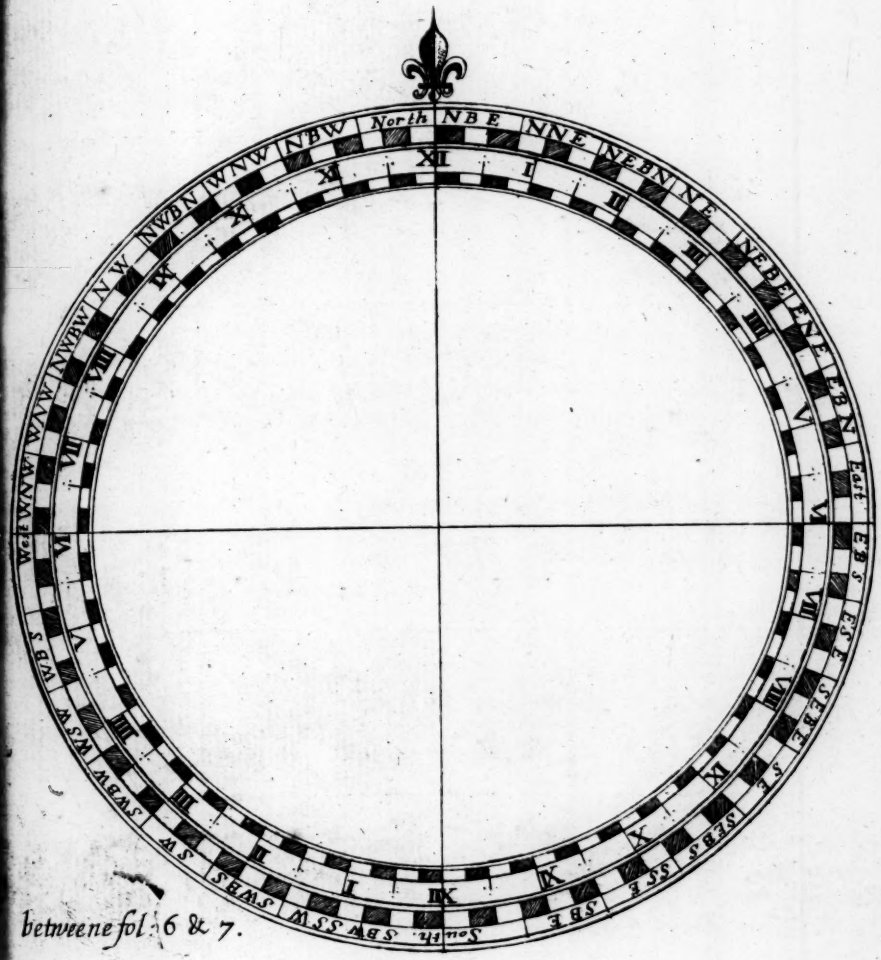
Here the Variation-Compaſs is to be placed.

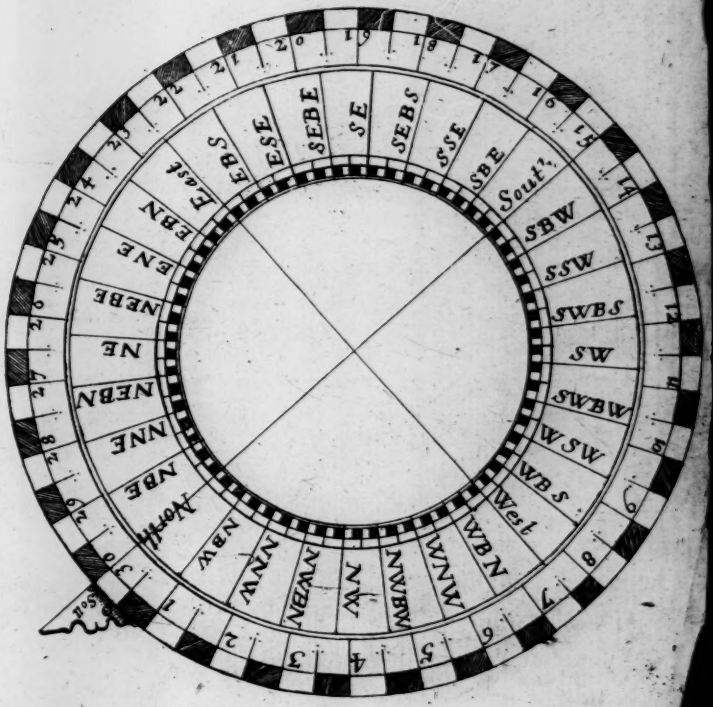
The Moon being 16 days old, I demand upon what Point of the Compaſs ſhe will be at 8 of the Clock at night.

In all Queſtions of this nature you have the Hour and Time given, and the Moons Age, to find the Point of the Compaſs. To anſwer theſe Queſtions, place the middle Index of *Sol* or the Sun on 8 of the Clock at night; then bring the upper Index of *Luna* or the Moon right over the 16th day of her Age, in the middle Circle of the Sun, and the Index of the Moon or upper Circle points to *E. b. S.* half a point Southerly, the true Point of the Compaſs the Moon will be, when ſhe is 16 days old, at 8 of the Clock at night.

PROP. II.

An Instrument Shewing ye Changing of ye Tides and ye Variation of ye Compas





betweene fol: 6 & 7.

PROP. II.

The Moon being 16 *days old, I demand, What is the Clock when ſhe is upon the* S. E. *Point?*

In Queſtions of this nature, you have the Point of the Compaſs, as well as the Moons Age: therefore turn the Index of the Moon to the South-Eaſt Point; keeping the Index faſt to the Point, bring the 16th. day of her Age in the middle Circle, right under *Luna*'s Index, and the Index of the Sun points and ſhews you 10 a Clock at night, that the Moon will be South-Eaſt.

PROP. III.

The Moon being S. E. b. S. *at* 8 *of the Clock at night, I demand, How many days old ſhe is?*

In ſuch like Queſtions, you muſt firſt put the Index of the Moon to the Point of the Compaſs South-Eaſt-by-South, and the Index of the Sun ſet to the Hour of the Night; then look where the Index of the Moon cuts the Circle of Days, and you ſhall find it cut the 13th. day of the Moons Age required.

PROP. IV.

The Moon being Eaſt-South-Eaſt, and the Sun Weſt-North-Weſt, I demand the Moons Age?

In all Queſtions of this nature, obſerve what you have given; then put the Index of the Moon to the *E. S. E.* Point, and hold it ſteady whilſt you put the Index of the Sun to Weſt-North-Weſt, and then look where the Index of the Moon cuts in the Circle of Days, and you ſhall find it cut the 15th. day of her Age, that is the Day ſhe was at the Full, and anſwereth the Queſtion deſired.

PROP. V.

The Moon being 17 *days old, I demand the time of the Day ſhe will be Eaſt-North-Eaſt?*

In all theſe ſorts of Queſtions, you muſt put the Index of the Moon to the Eaſt-North-Eaſt Point, ſtop it faſt there, and turn the Index of the Sun about until the 17th. day of her Age is under the Index of the Moon; then look what Hour the Index of the Sun is upon, and you will find it 6 a Clock; which anſwers you the time of the Day required.

This is worth your Obſervation, That if the Index points to the Eaſtward of the North and South, it ſhews the Morning 12 hours; if it points to the Weſtward of the North and South, it ſheweth the Evening 12 hours. Thus you ſee how ready the Practitioner in *Navigation* may have the Uſe of this Inſtrument, and by often practiſing it, may be in a ſhort time ſo imprinted in his mind, that as ſoon as he hath occaſion to uſe it, he will be able to reſolve it by memory, which is an excellent Ornament to a young Mariner. Therefore let ſo much ſatisfie for the Uſe of the Inſtrument in ſuch like Queſtions.

PROP. VI.

By the Inſtrument to find the time of Ebbing and Flowing, in any Port, River, or Creek.

Note. You are to obſerve juſt at the time of High-Tide, what Point of the Compaſs the Moon is upon that Day which ſhe changeth, in any Port, River, or Creek, where you would know the Ebbing and Flowing of the Tides, and time of High-Water or Full-Sea. This being found, you may know what Hour belongeth to that

that Point of the Compaſs, by turning the Index of the Moon, as before was ſhewed. So you may be ſure to have the Hour always under the Index, on the Change-day, throughout all the Points of the Compaſs; and ſo we ſhall proceed to Examples.

PROP. VII.

The Moon being 16 days old, I demand, What a Clock it will be Full-Sea at Briſtol, Start-point, Waterford, *where an Eaſt-by-South or Weſt-by-North Moon on the Change-day makes the Full-Sea?*

You are to conſider the Point of the Compaſs the Moon is upon in theſe Ports, when it is Full-Sea on the Change-day (as in all other Ports) which in theſe Ports is found by obſervation to be always Eaſt-by-South Moon (which is 6 hours 45 minutes) bring the Index of the Moon to the Weſt-by-North Point, ſtaying it there; bring the 16th. day of her Age under the Index of the Moon, and the Index of the Sun will point you to 7 of the Clock and half an hour paſt, the time of Full-Sea in the Morning. If it be the Evening Tide, bring the Index of *Luna* to the Eaſt-by-South, and ſtay it there, until you have brought 16 Days under the Index of *Luna*, and the Index of *Sol* will point directly upon half an hour after 7 of the Clock at Night, the time of Full-Sea in the aforeſaid Ports. So you may know in every other Port in the ſame manner, if you do as before directed. And take this for a Rule, That the Moon betwixt Change and Full is ever to the Eaſtward of the Sun, and riſeth by day, ſtill ſeparating it ſelf from the Sun until ſhe be at the Full: Then after the Full, in regard ſhe hath gone more Degrees in her ſeparation than is contained in a Semicircle, ſhe is gotten to the Weſtward of the Sun (riſing by night) and applieth towards the Sun again until the Change-day, which you may ſee plainly demonſtrated by the Inſtrument.

PROP. VIII.

The Moon being 16 days old, I deſire to know at what hour it will be Full-Sea at London, Tinmouth, Amſterdam, *and* Roterdam, *where a S. W. and N. E. Moon makes a Full-Sea upon the Change-day.*

It is found by obſervation, That the S. W. and N. E. Moon makes Full-Sea in all the aforeſaid Ports. When the Moon is to the Eaſtward of the Sun that is before her, bring the Index of the Moon to the S. W. Point; then turn the 16 day of her Age under the Moons Index, and the Index of the Sun anſwereth the Queſtion, That it is Full-Sea at all the aforeſaid Ports at 3 of the Clock and $\frac{1}{4}$ in the morning, the Moon being 16 days old.

PROP. IX.

At Yarmouth, Dover, *and* Harwich, *where a S. S. E. Moon maketh Full-Sea on the Change-day, the Moon being 9 days old, I demand the time or hour of Full-Sea that day in the aforeſaid places.*

Here it hath been found by experience, That a S. S. E. Moon makes Full-Sea on the Change-day, in the aforeſaid places; therefore bring the Index of the Moon to the S. S. E. Point, keep it there faſt directly on the Point, and bring the Moons Age to cut the edge of the Moons Index, and the Index of the Sun will ſhew you, That the time of Full-Sea in the aforeſaid Ports, will be at 5 a Clock and $\frac{1}{4}$ in the morning.

PROP. X.

At St. Andrews, Dundee, Lisbon, *and St.* Lucas, *where a South-Weſt-and-by-South Moon makes High-Water or Full-Sea on the Change-day; The Moon being 28 days old, I demand the time of Full-Sea that day in theſe places.*

You have here given you the *S.W.b.S.* Point of the Compaſs; therefore bring the Index of the Moon, and ſtay it on that Point, and bring the 28th. day of her Age under the edge of the Index of the Moon, and the Index of the Sun will point you out

out the time of Full-Sea, which is at half an hour paſt 12 of the Clock at noon, in the aforeſaid places. And ſo are all Queſtions of this nature anſwered. And ſo I will conclude the Uſe of this Inſtrument for finding the Ebbing and Flowing of the Tide, and ſo will proceed to ſhew you Arithmetically how to find the *Golden Number* or *Prime*, the *Epact*, and *Full*, *Change*, and *Quarters* of the *Moon*, and how to know her *Age* for ever; and what *Sign* and *Degree* ſhe is in the *Zodiack*, how long the *Moon* ſhineth, and what time of the day or night it is High-water or Full-Sea in any Port; and alſo the *Moon*'s Motion, as far as it is uſeful for Mariners.

How to find the Golden Number *or* Prime, *according to the* Julian, *or Old Account.* I.

YOu may obſerve this, That the *Prime* or *Golden Number* is a Revolution of 19 years, in which ſpace the ancient Aſtronomers were of opinion, that all the Aſpects between the *Sun* and *Moon* did return to the ſame point of the *Zodiack*, that they were in 19 years before. To find this uſeful Number, you muſt do thus: Always in that year you would know the *Prime Number*, add 1 to the date thereof, and then divide it by 19, and that which remaineth after the Diviſion is the Number required. As for example, --- In the year of our Lord 1665, I demand what is the *Prime Number*. Add to the year of our Lord always 1, which makes 1666; then divide that ſum by 19, the remain is the *Prime* or *Golden Number*, as you may ſee by the Work; ſo the *Prime* or *Golden Number* for that year is 13. This you ſee is very eaſie to do for any other year. Obſerve, That when you find nothing remaining after the Diviſion, that it is the laſt year of the *Moon*'s Revolution, and may conclude, that 19 is the *Prime* for that year. *Note.* The *Prime* beginneth always in *January*, and the *Epact* in *March*.

1 (1
x7
84 (3
x666 (87
x99
x

How to find the Epact, *according to the* Julian, *or Old Account, and what it proceedeth from.* II.

THe *Epact* is a Number that proceedeth from the difference which is made in the ſpace of one whole year, between the *Solar* year and the *Lunar* year. *Note.* The *Solar* year doth contain 365 days, 5 hours, 48 minutes; and the *Lunar* year (allowing 12 *Moons*, there being 29 days, 12 hours, 44 minutes between Change and Change) doth contain but 354 days, 8 hours, 48 minutes. So that there is almoſt 11 days difference between the Revolution of the *Sun* and *Moon*, at every years end; which difference makes the *Epact*. Therefore to find the *Epact* for any year, firſt you muſt know the *Prime Number* for that year, which we found before for the year 1665. to be 13. Then you muſt multiply this *Prime Number* 13. by 11. and it will make 143. which divide by 30. and there remaineth of the Diviſion, 23. which is the *Epact* for the year required. So I make no queſtion but that you underſtand how to find the *Prime* and the *Epact* for any year paſt, preſent, or to come. Therefore I hold this ſufficient to expreſs ſo facil a thing as this is. I have told you already, That the *Epact* always beginneth in *March*; but I ſhall make a ſmall Table for thoſe that are ignorant in *Arithmetick*, for 32 years to come, in the latter end of the Second Book.

11
13 (2
33 x4 (3 (4
11 30
143

A Rule to find the Change, Full, *and* Quarters *of the* Moon. III.

ADd unto the *Epact* of the year propoſed the number of the Months from *March*, including the Month of *March*, and ſubtract that ſum from 30. the remain ſheweth the day of the *Change*: But if the *Epact* be above 26. there this Rule faileth a day at the leaſt; but at other times it will be no great difference: Therefore it may ſerve for the following Concluſions.

As for Example, I desire to know the *New-Moon* in *October*, 1665. The *Epact* is 23. the Months from *March* are 8. which added makes 31. from it 30 subtracted, remains 1. which taken from 30. one whole *Moon*, there remains 29. So that the 29th. day of *October* is the day of her *Change*, or *New-Moon*, which by Calculation it is at 58 min. past 4 in the morning.

Having thus found the time of the *New-Moon*, you may from thence reckon the *Age* of the *Moon*, and so find the *Quarters*, or *Full-Moon*.

Thus the *Moon*'s *Age* is	Days,	Hours,	Min.
At the First Quarter	07	09	11
At the Full Moon	14	18	22
At the Last Quarter	22	03	33
At the Whole Moon	29	12	44

IV. *How to find the* Age *of the* Moon *at any time for ever.*

Add to the days of the Month you are in, the *Epact*, and as many days more as are Months from *March*, including *March* for one; and if these three Numbers added together exceed 30, take 30 from it as often as you can, and the remain is her *Age*: But if the Numbers added be under 30, that's her *Age*: As for Example, 1665. the *Epact* is 23. I demand, What *Age* the *Moon* is the 21th. day of *September*? From *March* to *September* is 7 Months, the *Epact* 23, and the day of the Month is 21; added together, makes 51; from it subtract 29, because the Month hath but 30 days in it, and the remain is 22, the *Age* of the Moon that day. Had it been the 22th. of *August*, and added them together, it would have made 51. Then to have taken 30 out, there had remained 21 for the *Moon*'s *Age* the 22th. day of *August*.

V. *How to find what* Sign *the* Moon *is in; with the* Moon's Motion *for every day of her* Age.

Astronomers divide the Compass of the *Heavens* into 12 *Signs*, which they set forth by these Names and Characters; *Aries* ♈, *Taurus* ♉, *Gemini* ♊, *Cancer* ♋, *Leo* ♌, *Virgo* ♍, *Libra* ♎, *Scorpio* ♏, *Sagittarius* ♐, *Capricornus* ♑, *Aquarius* ♒, *Pisces* ♓: which you must be a little acquainted with, and with the place of the *Sun* in the *Zodiack* in each of these *Signs*, which you have as followeth.

First know, That the *Sun* entreth the first *Sign* ♈ the 10th. of *March*, ♉ the 10th. of *April*, ♊ the 11th. of *May*, ♋ the 11th. of *June*, ♌ the 13th. of *July*, ♍ the 13th. of *August*, ♎ the 13th. of *September*, ♏ the 13th. of *October*, ♐ the 12th. of *November*, ♑ the 11th. of *December*, ♒ the 10th. of *January*, ♓ the 8th. of *February*. This known, the place of the *Sun* is well enough found by adding for every day past any of these, 1 *Degree*.

A Table shewing the Moon's Motion according to her Age.

D. Age.	S.	D.	M.	D. Age.	S.	D.	M.
1	00	13	11	16	07	00	49
2	00	26	21	17	07	14	00
3	01	09	32	18	07	27	11
4	01	22	42	19	08	10	21
5	02	05	53	20	08	23	32
6	02	19	04	21	09	06	42
7	03	02	04	22	09	19	53
8	03	15	26	23	10	03	03
9	03	28	35	24	10	16	14
10	04	11	46	25	10	29	25
11	04	24	56	26	11	12	35
12	05	08	07	27	11	25	46
13	05	21	18	28	00	08	56
14	06	04	28	29	00	22	07
15	06	17	39	30	01	05	17

For the *Sun* runs through these 12 *Signs* but once in a Year; the *Moon* in less than a Month, *viz.* in 27 days, 7 hours, 43 minutes. *Note*, That every *New Moon*, the *Sun* and *Moon* are in one *Sign* and *Degree*; but the *Moon* hath a Motion of about 13 *Degrees* every day, as is shewed in this Table. Therefore according to the Age of the *Moon*, add the *Signs* and *Degrees* of the *Moon*'s *Motion*, to the place of the *Sun* at the *New Moon*, and so you shall have the *Sign* and *Degree* which the *Moon* is in at any time desired.

Thus for Example, A *New Moon* 1665. the 26th. of *November*, and the *Sun* and *Moon* are both in 14 *Degrees* of

of ♐. Now upon the the 11th. of *December*, the *Moon* being 14 days old, I would know what *Sign* the *Moon* is in. This Table ſhews, for the 14 day of the *Moon*'s *Motion*, you muſt add 6 *S.* 4 *D.* 28 *Min.* to the ſaid 14 *Degrees* of ♐.

Now counting thoſe 6 *Signs* upon your Fingers, reckoning the Names of the *Signs* in order from *Sagittarius*, ♑ 1, ♒ 2, ♓ 3, ♈ 4, ♉ 5, ♊ 6, it falls upon the *Sign Gemini*. Laſtly, adding the odd 14 *Degrees* unto the 4 *Deg.* of the *Moon*'s *Motion* together, ſhews the place of the *Moon* to be in 18 *Degrees* of *Gemini*.

There is much uſe made of the *Moon*'s being in ſuch and ſuch *Signs*, in *Phyſick* and *Huſbandry*, of which I ſhall ſay nothing; but give you one Concluſion which much depends hereon; that is,

To know the time of the Moon's Riſing, Southing, *and* Setting.

FOr her *Riſing* (know this) having found the place, or what *Sign* ſhe is in, ſeek out in the following *Kalendar* what time the *Sun* is in this *Sign* and *Degree*, and there you ſhall find the true time of the *Sun-Setting*, being in that place: add this to the time of the *Moon*'s coming to the *South*, it ſhews the time of her *Setting*; and ſubtracted from it, ſhews the time of her *Riſing*.

Thus upon the 11th. of *December*, as before, the *Moon* being 14 days old, and in the 18 *Degree* of *Gemini*, I deſire to know the time of the *Moon*'s *Riſing* and *Setting*.

Firſt multiply 14, the *Moon*'s *Age*, by 4, divide the Product by 5; in the Quotient will be 11 a Clock, and $\frac{4}{5}$, which is 12 min. that the *Moon* will be *South* that night. Secondly, The *Sun* is in this *Sign* and *Degree* about the 30th. of *May*, and then ſets at 8 a Clock and 10 minutes paſt. This ſubtracted, ſhews the *Riſing* of the *Moon* to be at 3 of the Clock 2 minutes in the afternoon. The ſaid 8 hours, 10 being added, makes 19 hours 22 minutes, which by caſting away 12, the remain ſhews the *Moon*'s *Setting* to be at 7 of the Clock, and 22 min. paſt in the morning, which anſwers the Queſtion deſired; which may ſerve for ordinary uſe.

		H.	*M.*
☾	*So.*	11	12
☉	*Set.*	8	10
☽	*Riſ.*	3	02
	Added	19	22
☾	*Set.*	7	22

PROP. I.

How to find when it is Full-Sea *in any* Port, Road, Creek, *or* River.

I have ſhew'd you already how to find the *Prime*, *Epact*, and *Age* of the *Moon*, at any time deſired. Now we will proceed to ſhew you the finding of *Full-Sea* in any Place; as in manner following. — *Firſt*, Carefully obſerve the time of *High-Water* on the *Change* or *Full* of the *Moon*, in that *Port* or Place where you would know the time of the *Full-Sea*, or find by the *Table* what *Moon* makes a *Full-Sea* in the ſaid *Port*. *Secondly*, Conſider the *Age* of the *Moon*; then by *Arithmetick* reſolve it in this manner: Multiply the *Moon*'s *Age* by 4, divide the Product by 5, the Quotient ſhews the *Moon*'s *Southing*; if any thing remain upon the Diviſion, for every Unit you muſt add 12 Min. if it was 4 remaining, it would be 48 Min. to be added; then add the hour that it Flows on the *Full* or *Change* to it, and the Total is the hour of *Full-Sea*: if it exceed 12, ſubtract 12 from it, the remainder is the hour of the day or night of *Full-Sea*, in any *Port*, *River*, or *Creek*. Which I will make plain by ſome *Examples*, (viz.)

PROP. II.

The Moon 16 *days old*, *I demand*, *What a Clock it will be* Full-Sea *at* Briſtol, Start-Point, *and* Waterford, *where an* E. b. S. *and* W. b. N. Moon *maketh* Full-Sea *on* Change *or* Full *of the* Moon.

Conſider here an *E. b. S. Moon* maketh 6 hours 45 minutes, and the *Age* of the *Moon* is 16 days old: Therefore multiply the *Age* by 4, and it makes 64; divide that by 5, and it is 12, and 4 remaineth, which is 48 min. To it add 6 hours 45 minutes *E. b. S.* it makes 19 hours 33 minutes. Therefore ſubtract 12 hours from it, there remaineth 7 a Clock 33 minutes, the time of *Full-Sea* in the morning at the aforeſaid *Ports*; which you may compare with your *Inſtrument*, and find it very well agree.

☾ *Age* 16
4
64

x(4 *h.* *m.*
64 (12 48
56

E. b S.	6	45
Total	19	33
Subtr.	12	00
Full-Sea,	7	33

PROP. III.

The Moon *being* 25 *days old*, *I demand*, *What a Clock it will be* Full-Sea *at* London, Tinmouth, Amſterdam, *and* Roterdam, *where it flows* S. W.

Conſider that at theſe Places on the *Full* or *Change-days* at *S. W. Moon* maketh *Full-Sea*, which is 3 hours. Therefore multiply 25, the *Moon's Age*, by 4, it makes 100. That divide by 5, in the Quotient will be 20, and nothing remain. To it add 3 ho. *S. W.* and it makes 23 hours. From it ſubtract 12, and the Remainder ſhews you, That it will be *Full-Sea* at all the aforeſaid Places, at 11 of the Clock in the morning. So you will find it agree with your Inſtrument.

Age D 25
4
100
☌
100 (20
58 3 *S. W.*
23
12
11 *Full-Sea.*

PROP. IV.

The Moon *being* 9 *days old*, *I deſire to know the hour of* Full-Sea *at* Quinborough, Southampton, *and* Portſmouth.

Note, That a *South-Moon* on the *Full* or *Change-day*, maketh *Full-Sea* at theſe Places. Therefore multiply the *Moon's Age* by 4, it makes 36; that divide by 5, and the Quotient is 7 of the Clock; and 1 remaineth, which is 12 minutes, the time of *Full-Sea* at the aforeſaid Places, the *Moon's Age* being nine days. *Note*, If a *North* or *South Moon* makes *Full-Sea* on the *Full* or *Change-day*, there is nothing to be added to the Quotient; but the Quotient is the hour of the day, and the Remainder is the min. as before directed. One Example more ſhall ſuffice.

9
4
36
(1
5 (7 12

PROP. V.

The Moon 5 *days old*, *I demand the time of* Full-Sea *at* Rocheſter, Malden, Blacktail, *where* S. b. W. Moon *is* Full-Sea.

Here you may note, That on the *Full* or *Change-day* at theſe Places it flows *S. b. W.* which is but one Point from the *South*; being but $\frac{1}{4}$ of an hour, or 45 min. (And it had been all one if it had been *North-by-Eaſt.*) Multiply by 4, divide by 5, and the Quotient will be 4; to it add 45 min. *S. b. W.* ſhews you it will be *Full-Sea* at the aforeſaid Places at 4 a Clock and 45 min. in the morning. By this time I hope I have made the *Practitioner* able to know the time of *Full-Sea* in any *Port*, by *Inſtrument* and *Arithmetick*. Therefore I will leave him a ſmall *Table* for his uſe.

A TIDE-TABLE.

	H.	*M.*
Rye, *Winchelſey*, *Culſhot*, a S. b. E. Moon.	11	15
Rocheſter, *Malden*, *Blacktail*, S. b. W.	0	45
Yarmouth, *Dover*, *Harwich*; S. S. E.	10	30
Graveſend, *Downs*, *Blackneſs*, *Silly*, S. S. W.	1	30
Needles, *Orford*, *South* and *North Fore-land*, S. E. b. S.	9	45
Dundee, *St. Andrews*, *Liſbon*, *St. Lucas*, S. W. b. S.	2	15
Pool, Iſles of *Man*, *Dunbar*, *Diep*, S. E.	9	00
London, *Tinmouth*, *Amſterdam*, *Roterdam*, S. W.	3	00
Portland, *Hartflew*, *Dublin*, S. b. W.	8	15
Barwick, *Fluſhing*, *Hamborough*, S. W. b. W.	3	45
Milford, *Bridgewater*, *Lands-end*, E. S. E.	7	30
Baltimore, *Corke*, *Severn*, *Calice*, W. S. W.	4	30
Briſtol, *Start-point*, *Waterford*, E. b. S.	6	45
Falmouth, *Humber*, *Newcaſtle*, W. b. S.	5	15
Plimouth, *Hull*, *Lyn*, *St. Davids*, W. & E.	6	00
Quinborough, *Southampton*, *Portſmouth*, N. & S.	0	00

Add any two Numbers together of the foregoing *Table*, and they ſhall be 12 hours; Except the two laſt, *N. S.* and *E. W.* And what hath been ſaid from the *South*, either

either *Eaſtward* or *Weſtward*, the ſame anſwereth to the *North*, either *Weſtward* or *Eaſtward*. And ſo much for the *Tides*. But we will know the *Moon's Motion*, and the Proportion between *Tide* and *Tide*.

PROP. VI.

The Motion *of the* Moon, *and the Proportion of Time betwixt* Tide *and* Tide.

After all this, I will ſhew you in brief the *Motion* of the *Moon*, and the reaſon of the difference between *Tide* and *Tide*.

You muſt note, the *Motion* of the *Moon* is twofold. *Firſt*, A *Motion*, which is from *Eaſt* to *Weſt*, cauſed by the diurnal ſwiftneſs of the *Primum Mobile*. *Secondly*, Her own *Motion* in the *Zodiack* from *Weſt* to *Eaſt*, which the *Moon* performeth in 27 days, 8 hours, 8 minutes; in which ſpace ſhe returns to the ſame point of the *Zodiack* from whence ſhe departed. But to come to the ſame Point where ſhe was in Conjunction with the *Sun* laſt (by reaſon the *Sun's Motion* every day is Eaſt, 1 Degree) the *Moon* muſt move longer 2 days, 4 ho. 36 min. more than her natural *Motion*, before ſhe can overtake the *Sun*, to come into Conjunction with him; ſo that betwixt *Change* and *Change* is 29 days, 12 hours, 44 minutes, by my account. The *Mariner* always allows juſt 30 days between the *Changes*, by reaſon he will not be troubled with ſmall Fractions of Time, in this Account of *Tides*, which breedeth no great error: Reaſon therefore muſt needs ſhew me this, That I muſt allow, according to that Proportion, the *Moon* in every 24 hours to depart from the *Sun* 12 Degrees, (which is 48 min. of time.) Now if the *Moon* move in 24 hours, 48 min. then in 12 hours ſhe muſt move 24 min. and in 6 hours, 12 min. and by this proportion each hour ſhe moveth 2 min. and ſo the *Tides* differ as the time differs.

I will add one old approved Experience for the *Mariners* uſe, though it is impertinent in this place, that is, To cut Hair in the *New* of the *Moon*; cutting, ſhaving, clipping in the *Wane*, cauſeth baldneſs. So I hope I have ſatisfied the *Learner* concerning the *Moon*.

CHAP. III.

The Practick Part of Navigation, *in working of a* Ship *in all Weathers at* Sea.

WE have been ſhewing the *Practitioner* all this while, the *Courſe* and *Motion* of the *Moon*, and ſo by it to know how to ſhift the *Tides*, or time of *High-Water*, in any *Port*, *Road*, *Harbour*, or *Creek*, Inſtrumentally and Arithmetically. The next thing to be obſerved by a *Learner*, is the *Words* of *Command*, with readineſs to anſwer and obey, which is the moſt excellent Ornament that can be in a Compleat *Navigator*, or *Mariner*. And as Captains Exerciſe their Men on Shore, that their Souldiers may underſtand the Poſtures of War, and to execute it, when the Word of Command is given by their Commander: In like manner are *Sea-men* and *Mariners* brought up in Practical Knowledge of *Navigation* at *Sea*, in working a Ship in all Weathers. Although the Rules here demonſtrated are but of little benefit to him, that hath been brought up all his Life-time at *Sea*; and leſs to thoſe that be altogether ignorant in *Marine Affairs*: But that the *Practick* may be delivered in proper *Sea-Phraſes*, according to each ſeveral Material that belongs to a *Ship* compleatly rigg'd, with the Uſe of the ſeveral Ropes in working and trimming of Sails at *Sea* on all Occaſions, cannot be denied by thoſe that know theſe things perfectly: Therefore it is impoſſible for any Man to be a Compleat *Mariner* or *Navigator*, without he hath attained to the true Knowledge of *Theorick* and *Practick*, being both *Siſters* and inſeparable *Companions*, that makes them perfect *Navigators*; Therefore I could not let this ſcape my Pen.

And to explain my ſelf, that I may prevent the Cenſures of all ſuch that will be curious, inquiring whether I am not lame, or incapable of that, and like themſelves appear imperfect; I may ſpeak it with trouble to my ſelf, and ſhame to others, That there

there was never more lame and decrepit Fellows preferred by *Favour* and *Fortune*, as alſo by *Kindred*, and by Serving for Under-Wages as now adays. Let a man go aboard the beſt Ship at Sea, and it will be very rare to find *Ignorance* out of the Officers Cabins, and commonly able *Mariners* and more ſufficient men before the Maſt, who are forced to hawl a bowling, through the averſeneſs of their Fates, which is great pity. I ſhould be glad to live to ſee a more equaller *Balance* among *Sea-men*, and their *Imployers*, to further the induſtrious, and encourage the deſerving Men; for if this partiality ſhould continue long, it is to be feared, in ſome ſhort time, the *Compleat Mariner* will be hardly found aboard any Ship, to the great diſparagement of our *Engliſh* Nation, which hath from time to time ſo long deſervingly had the *Superiority* over all other parts of the World, for breeding the moſt famous *Navigators*. The *Hollander* to his Loſs knows it right well, that there are none like *Engliſh* for Courage at *Sea*; but that many of them out-ſtrip us in the Art of *Navigation*, which proceeds from the former unequal *Balance*, which makes our expert *Sailers* to ſeek, if *Fortune* will be favourable amongſt them; or elſe they had not at this day been *High* and *Mighty*, and in ſuch a flouriſhing Condition as now they are. Therefore I hope to ſee and hear, That the *Engliſh Mariner* will make better uſe of ſwift-ſtealing *Time*, that he may redeem what is loſt, and attain to ſuch perfection, as that he may parallel his *Art* with his *Valour* and *Courage*; And that *Imployers* will uſe more Equity, in placing deſerving men according to their merit. I ſhall not draw out my digreſſion to any longer diſcourſe; for I know my plain *Rhetorick* will not reliſh in ſome mens ears, though it may in others: Therefore I ſhall draw to a concluſion, deſiring that no man will cenſure me, before he knows what is in me, or is able to mend this. For ſome there are, being a little touched (as the common ſaying is) that if they had me at Sea, they would put me to ſeek all my preſcribed Rules; but I would have ſuch to know, That when I am at Sea, I ſhall work the Ship in all Aſſays as well as ever they did, and can as often as I ſhall be called thereunto, after this manner, *(viz.)*

PROP. I. *The Wind is fair.*

The Wind is fair, though but little; it comes well, as if it would ſtand; therefore up a hand and looſe fore Top-ſail in the Top, that the Ships may ſee we will Sail; Bring Cable to the Capſton, heave up your Anchor, looſe your Fore-ſail in the Brailes; put abroad our Colours, looſe the Mizen in the Brailes. Is all our men on board? Thoſe that be on Shore may have a Tow, and be bleſt with a Ruther; for we will ſtay for no man. Come my Hearts, heave up your Anchor, that we may have a good Prize. Come, Who ſay *Amen?* One and all. Oh brave Hearts, the Anchor is a Peck; heave out Fore-top-ſail, heave out Main-top-ſail, hawl home the Top-ſail Sheets. *The Anchor is away*, let fall your Fore-ſail, hoiſe up your Foretop-ſail, hoiſe up your Main-top-ſail; up and looſe the Main-ſail, and ſet him; looſe Sprit-ſail, and Sprit-ſail Top-ſail. A brave Gale. Bring the fore-Tack to the Cat-head, and trim our Sails quartering; hoiſe up our ſmall Sails, heave out the Mizen-top-ſail and ſet him. Now we are clear, and the Wind like to ſtand; hoiſe in our Boats before it is too much Sea, aboard Main-tack, aboard Fore-tack, a Lee the Helmne handſomly, and bring her to eaſily, that ſhe may not ſtay. Brace the Fore-ſail and Fore-top-ſail to the Maſt, and hawl up the Lee-Bowlings, that the Ship may not ſtay; paſs Ropes for the Boats on the Lee-ſide, and be ready to clap on your Tackle, and hoiſe them in; ſtow them faſt. Let go the Lee-Bowling of Fore-ſail, and Weather-Braces. Right you Helmne, hale aft the Fore-ſheet, trim the Sails quartering as before: Looſe Sprit-ſail, and hale aft the Sheets; and hoiſe up the Sprit-ſail-top-ſail, and other ſmall Sails. Set the Main-ſtay-ſail, and Fore-top-ſail-ſtay-ſail, and Mizen-ſtay-ſail, and Main-top-ſail-ſtay-ſail, and lace on your Boonets, that we may make the moſt of our way. To our Station; clear your Ropes. Come, get up our ſteering Sails. The Lee ſteering Sails of Main-ſail, and Main-top-ſail, Fore-ſail and Fore-top-ſail only; for they will ſit faireſt, and draw moſt. I have on purpoſe omitted ſeveral Words, by reaſon I would not trouble the *Reader* with ſuch indifferent things as are conceived by all *Mariners* to be done; as Cooning the Ship, Bracing Veering,

Veering, and Haleing aft, Hoiſing, Looring, and the like: but it is to be ſuppoſed that all this is done. Thus you have a brave Ship under all her Sails and Canvas, in her ſwifteſt way of Sailing upon the Sea. Now let us have her right before the Wind.

Right afore the Wind, and a freſh Gale.

The Wind is vered right aft, take in your Fore and Fore-top-ſail-ſteering-ſail, and Fore-top-ſail, and Main and Main-top-ſail-ſtay-ſails; for they are becalmed by the After-ſails, and will only beat out. The Wind blows a freſh Gale, round aft the Main-ſheets, and Fore-ſheets, ſquare your Yards, take in your Main and Main-top-ſail, Steering-ſails. Unlace your Bonnets. Take in your Main and Fore-top-gallant-ſails; in Sprit-ſail, and Mizen-top-ſail, let go the Sheets, hale home your Clew-lines, caſt off Top-gallant-bowlings. Thus you have all the ſmall Sails in, and furled, when it blows too hard to bear them.

The Wind vereth forward, and ſcanteth.

The Wind ſcanteth, vere out ſome of your Fore and Main-ſheets, and Spriſle-ſheets, and let go your Weather-braces; tope your Sprit-ſail-yard. The Wind ſtill vereth forward; Get aboard the Fore and Main-tack; caſt off your Weather-ſheets and Braces: The Sails are in the Wind, hawl off Main and Fore-ſheets; the Wind is ſharp, hawl forward the main Bowline and fore Bowline, and hawl up the Main-top-ſail and Fore-top-ſail Bowline, and ſet in your Lee-braces, and keep her as near as ſhe will lie. Thus have you all the Sails trimm'd ſharp, and by a Wind.

The Wind blows Friſking.

The Wind blows hard; ſettle our Fore and Main-top-ſails two thirds of the Maſt down. It is more Wind, come, hawl down both Top-ſails cloſe. Come, ſtand by, take in our Top-ſails: Let go the Top-ſail Bowlines, and Lee-braces; let go the Lee-ſheets, ſet in your Weather-braces, ſpill the Sails, hawl home the Top-ſail Clewlines, ſquare the Yard. Now the Top-ſails are furled, and you have the Ship in all her low Sails, or Courſes.

It bloweth a Storm.

It is like to over-blow; Take in your Sprit-ſail, ſtand by to hand the Fore-ſail. Caſt off the Top-ſail Sheets, Clewgarnets, Leechlines, Buntlines; ſtand by the Sheet, and brace; lowr the Yard and furl the Sail; here is like to be very much Wind: See that your main Hallyards be clear, and all the reſt of your Geer clear and caſt off. (It is all clear.) Lowr the Main-yard, hawl down upon your down-hawl; now the Yard is down, hawl up the Clewgarnets, Lifts, Leachlines, and Buntlines, and furl the Sail faſt, and faſten the Yards, that they may not traverſe and gall. Thus have you the Ship a trije under a Mizen.

A very hollow grown Sea.

We make foul weather, look the Guns be all faſt, come hand the Mizen. The Ship lies very broad off; it is better ſpooning before the Sea, than trying or hulling; go reef the Fore-ſail and ſet him; hawl aft the Fore-ſheet: The Helmne is hard a weather, mind at Helmne what is ſaid to you carefully. The Ship wears bravely ſteady, ſhe is before it; belay the fore doon hall, it is done. The Sail is ſplit; go hawl down the Yard, and get the Sail into the Ship, and unbind all things clear of it. *Starboard*; hard up, right your Helmne, Port, Port hard, more hands, he cannot put up the Helmne. *A very fierce Storm.* The Sea breaks ſtrange and dangerous; ſtand by to hawl off upon the Lannierd of the Whipſtaff, and help the man at Helmne, and mind what is ſaid to you. Shall we get down our Top-maſts? No, let all ſtand. She ſcuds before the Sea very well; the Top-maſt being aloft the

the Ship is the holſomeſt, and maketh better way through the Sea, ſeeing we have Sea-room. Thus you ſee the Ship handled in fair Weather and foul, by and large. Now let us ſee how we can turn to Windward.

The Storm is over, let us turn to Windward.

The Storm is over, ſet Fore-ſail and Main-ſail; bring our Ship to; ſet the Mizen, the Main-top-ſail, and Fore-top-ſail. Our Courſe is *E. S. E.* the Wind is at *South:* Get the Starboard-tacks aboard, caſt off our Weather-braces and Lifts; ſet in the Lee-braces, and hawl forward by the Weather-bowlings, and hawl them taught and belay them, and hawl over the Mizen-tack to Windward; keep her full, and by as near as ſhe will lye. *How Wind you? Eaſt.* A quade Wind: No near, hard no near: The Wind vereth to the *Eaſtward* ſtill. *How Wind you? N. E.* Hard, no near. The Wind is right in our teeth; no near ſtill. *How Wind you? N. W. b. N.* The Wind will be *Northerly*, make ready to go about; we ſhall lye our Courſe the other way, no near, give the Ship way, that ſhe may ſtay: Ready, ready, a-lee the Helm, vare out the Fore-ſheet, caſt off the Lee-braces of your Fore-ſail and Fore-top-ſail, brace in upon your Weather-braces, let go Fore-top-bowline. The Fore-ſails is a-back-ſtays, hawl Main-ſail, hawl, let riſe the Main-tack; caſt off your Larboard-braces; let go Main-bowline, and Main-top-ſail-bowline; brace about the Yard, hawl forward by the Larboard-bowlines; get the Main-tack cloſe down, in the Cheſs-tree: the Sheet is cloſe aft; hawl, off all; hawl; get to Fore-tack, let go Fore-bowline, and Fore-top-ſail-bowline; hawl aft the Fore-ſheet, hawl taught the Main-bowline, and Main-top-ſail-bowline; ſhift the Mizen-tack, hawl taught Fore-bowline, and Fore-top-ſail-bowline; ſet in the Lee-braces fore and aft, keep her as near as ſhe will lye. — No near, *How Wind you? N. N. E.* thus, ware no more; no near, keep her full. The Wind is at *N. N. E.* thus, ware no more. *(How Wind you?) E. N. E.* The Wind is at *N.* keep her away her Courſe *E. S. E.* Caſt off the Lee-braces and Weather-bowlines, and ſet in your Weather-braces. Vere out the Main-ſheet, and Fore-ſheet, looſe the Sprit-ſail, and Sprit-ſail-top-ſail, and Mizen-top-ſail, and Top-gallant-ſails; hoiſe them up, the Wind veres aft ſtill; let riſe the Fore-tack: the Wind's quartering, hawl aft the Fore-ſheet, bring it down to the Cat-head with a paſs-a-ree; ſteddy in your Weather-braces; the Wind ſtands. Thus you have the Ship as at firſt, ſteering under all her Canvas, quarter Wind: ſhe hath been wrought in all manner of Weather, and all ſorts of Winds. Therefore we will draw to a concluſion with a Man of War in Chaſe and taking of her Prize, and ſo leave this Practick Part to your Cenſure.

The Man of War in her Station.

Now we are in our Station, and a good *Latitude*, hand your Top-ſails and furl your Main-ſail and Fore-ſail, and brail up the Mizen, and let her lie at Hull, until Fortune appear within our *Horizon.* Up aloft to the Top-maſt-head, and look abroad, young men; look well to the *Weſtward*, if you can ſee any Ships that have been nipt with the laſt *Eaſterly* Winds. *A Sail, a Sail.* Where? Fair by us. How ſtands ſhe? To the *Eaſtward*, and is two Points upon her Weather-bow, and hath her Larboard-tacks aboard. O then ſhe lies cloſe by a Wind; we ſee her upon the Decks plainly. A good man to Helm. Up young men, and looſe the Fore-ſail, Main-ſail, and Mizen. Get the Larboard-tacks aboard; heave out the Main-top-ſail, and Fore-top-ſail, and looſe the Sprit-ſail. Keep her as near as ſhe will lie; hawl aft the Sheets, and hawl up your Bowlines taught. Do you ſee your Chaſe? Yea. *How Wind you? E. N. E.* Then the Wind is at *N.* Hoiſe up your Top-ſails as high as you can; heave out Sprit-ſail-top-ſail, and Mizen-top-ſail; hawl home the Sheets, and hoiſe them up: A young man looſe the Main-top-gallant-ſail, and Fore-top-gallant-ſail; hawl home the Sheets, and hoiſe them up; hoiſe up Main-ſtay-ſail, and Mizen-ſtay-ſail, and looſe the Main-top-ſail, and Fore-top-ſail-ſtay-ſails, and ſet them. It blows a brave chaſing Gale; The Ship makes brave way through the Sea,

Sea, we raiſe her apace; if ſhe keep her Courſe, we ſhall be up with her in three Glaſſes. No near, keep the Chaſe open with the Litch of the Fore-ſail. So, thus, keep her thus. Come aft all hands, the Ship will Steer the better when you ſit all quiet, by her ſmall Sails; for ſhe is too much by the Head. The Chaſe is a luſty brave Ship. So much the better, ſhe hath the more Goods in her Hold. The Ship hath a great many Guns, it may be ſhe's a Privateer. ---- *Port*, the Chaſe is about, come fetch her Wake, and we will be about after her. We Sail far better than ſhe; we have her Wake, a-ſee the Helm, vere out Fore-ſheet. Every man ſtand handſomly to his buſineſs, and mind the Bowlines and Braces, Tacks and Sheets; hawl Main-ſail, hawl. Let go Main-bowline, Top-bowline, Top-gallant-bowline; hawl of all, hawl, ſhifts the Helm; bring her to, hawl the Main-ſheet and Fore-ſheet cloſe aft. Set in the Lee-braces, hawl taught the Bowlines. The Chaſe keeps cloſe upon a Wind; keep her open under our Lee. *Gunner*, ſee that you have all things in readineſs, and that the Guns be clear; and that nothing peſter our Decks. ---- Down with all Hammocks and Cabins that may hinder and hurt us. *Gunner*, is all our Geer ready? Is there ſtore of Cartrages ready fill'd, all manner of Shot at the Main-maſt? Is there Rammers, Sponges, Ladles, Priming-irons, and Horns, Lintſtocks, Wads, and Water at their ſeveral quarters ſufficient for them? Be ſure that none of our Guns be cloy'd; and when we are in Fight, be ſure to load our Guns with Croſs-bar and Langrel. Always obſerve to give Fire when the Word is given. See that there be Half-pikes and Javelins in a readineſs, and all our Small-ſhot well furniſhed, and all their Bandaleers fill'd with Powder, and Shot in their Pooches. See that our Murtherers and Stockfowlers have their Chambers fill'd with good Powder, and Bags of Small-ſhot to load them, that if we ſhould be laid aboard, we might clear our Decks. Starboard, the Chaſe pays away more room, Starboard hard; Vere out ſome of the Main-ſheet and Fore-ſheet; Caſt off the Larboard-braces, Steddy, Keep her thus: Well Steer'd; the Chaſe goes away room, her Sheets are both aft, ſhe is right before the Wind: Stereboard hard; Let riſe Main-tack, let riſe Fore-tack; Hawl aſle Main-ſheet, hawl aft Fore-ſheet. We have a Stern-chaſe, but we ſhall be up with her preſently, for we fetch upon her hand-going. The Chaſe hawls up his Main-ſail and furls it; ſhe puts aboard her Waſt-clothes; ſhe will fight us. Come up young men, and furl our Main-ſail; ſling our Main-yard, with the Chains in the Main-top; ſling our Fore-yard, put aboard our Waſt-clothes; he will fight us before the Wind; I ſee ſhe is full of Men; It is a hot Ship, but deep and foul. Come chearly my Hearts, it is a Prize worth fighting for; The Chaſe takes in her ſmall Sails; Up aloft and take in our Top-gallant-ſails, Sprit-ſail-top-ſails, Mizen-top-ſail, and furl the Sprit-ſail, and get the Yard alongſt under the Bowſprit. She puts aboard her Colours, it is Red, White, and Blew; they are *Dutch* Colours, no force; Boy, up and put abroad St. *George*'s Colours in our Main-top; ſtep aft a-hand, and put abroad our Ancient; Call all hands aloft; Come up aloft all hands. They are all up Captain.

Gentlemen, *We are here employed and maintained by His Majeſty King* CHARLES *and our Countrey, to do our Endeavours to keep this Coaſt from* Pyracy *and* Robbery, *and His Majeſties Enemies; and it is our fortune to meet this Ship at this time: Therefore I deſire you in His Majeſties Name, and for the ſake of our Countrey, and the Honour of our* Engliſh *Nation, and our ſelves, for every man to behave himſelf courageous like* Engliſhmen; *and not to have the leaſt ſhew of a Coward: but to obſerve the Words of Command, and do his utmoſt endeavour. Into God's hands we commit our Cauſe, and our ſelves. So every man to his Quarters, and ſhew his Courage, and God be with you.*

She ſettles her Top-ſails, we are within ſhot; let all our Guns be looſe; in the Tackles; and the Ports all knockt open, that we may be ready to run out our Guns when the Word is given. Up noiſe of Trumpets and hail our Prize; ſhe anſwereth again with her Trumpet: Hold faſt Gunner, do not fire till we hail them with our Voices. *Port*, Edge towards him, he fires his Broad-ſide upon us. What chear my Hearts? Is all well betwixt Decks? *Yea*, *Yea*, only he rackt us through and

through. No force, it is his turn next; but give not Fire until we are within Piſtol-ſhot. *Port*, edge towards him. He plies his Small-ſhot; hold faſt Gunner. *Port*, right your Helm. We will run up his Side. Starboard a little; Give Fire, Gunner. That was well done. This Broad-ſide hath made their Deck thin, but the Small-ſhot at firſt did gaul us. Clap in ſome Caſe-ſhot in the Guns you are now a loading. Brace too the Fore-top-ſail, that we may not ſhoot a-head: He lies broad off to the Southward, to bring his other Broad-ſide to bear upon us. Starboard hard. Get to Larboard Fore-tack; trim your Top-ſails; run out your Larboard Guns. He fires his Starboard Broad-ſide upon us, he pours in his Small-ſhot. Starboard, give not fire until he fall off, that the Prize may receive our full Broad-ſide. Steady: *Port* a little; give Fire, Gunner: His Fore-maſt is by the board. This laſt Broad-ſide hath done great Execution. Cheerly my Mates, the day will be ours; He is ſhot a-head; He bears up before the Wind to ſtop his Leaks: Keep her thus; Well Steered. *Port*, *Port* hard; Bear up before the Wind, that we may give him our Star-board Broad-ſide. Gunner, Is there great ſtore of Caſe-ſhot and Langrel in our Guns? *Yea*, *Yea*. *Port*, make ready to Board him; Have your Laſhers clear, and able men with them. Edge towards him when you give Fire: Bring your Guns to bear amongſt his Men with the Caſe-ſhot. Well Steered, we are cloſe on board. Give Fire, Starboard, Well done Gunner; They lie Heads and Points aboard the Chaſe. Come, A-board him bravely; *Enter*, *Enter*. Are you laſhed faſt? *Yea*, *Yea*, We will have him before we go here-hence. Cut up the Decks; Ply your Hand-Granadoes and Stink-Pots. He cries out Quarter; *Quarter for our Lives, and we will yield up Ship and Goods.* Good Quarter is granted, provided you will lay down all your Arms, open the Hatches, hawl down all your Sails and furl them; looſe the Lachings, we will ſheer off our Ship, and hoiſe out our Shallop. If you offer to make any Sail, expect no Quarter for your Lives. Go with the Shallop, and ſend aboard the Captain, Lieutenant, and Maſter and Mates, with as many more as the Shallop will carry. So we will leave the *Man of War* to his Prize, and to ſecure his Priſoners. And now I have ſhewn you thus much of the Practick part of *Navigation*, in which you may perceive that I have wrought the Ship in all Eſſays, in Words and proper Sea-Phraſes; and if I were at Sea, I ſhould perform it both in Word and Deed: therefore I leave it all to your Judicious Cenſures. And ſo I will conclude with *Ovid*, when he ſailed in the *Ionian* Streights.

Nothing but Waves we view in Sea where Ships do float,
And Dangers lie, huge Whales, and all Fiſh play:
Above our Heads, Heaven's Star-embroidered Coat,
Whoſe Vault contains two Eyes, for Night and Day;
Far from the Main, or any Marine Coaſt,
'Twixt Borean *Blaſts, and Billows, we are toſt.*

If Ovid *in that ſtraight* Ionian *Deep*
Was toſt ſo hard, much more are we on Seas
Of larger Bounds, where Staff *and* Compaſs *keep*
Their ſtrict obſervance: Yet in this uneaſe
Of Tacking Boards, we ſo the way make ſhort,
That ſtill our Courſe draws nearer to our Port.

Between the Stream and ſilver-ſpangled Skie
We rolling climbe, then hurling fall beneath;
Our way is Serpent-like, in Meads which lie,
That bows like Graſs, but never makes a Path:
But fitter, like young Maids and Youths together,
Run here and there, all where, and none know whether.

Our way we know, and yet unknown to other;
And whiles misknown to us, before we dive:
The Hand and Compaſs *that governs the* Ruther
Do often erre, although the Pilots *ſtrive*
With Chart *and* Compaſs, *yet our Reck'nings fall*
Too narrow, ſhort, to high, too wide, too ſmall.

To diſcon this, remark when we ſet Land,
Some this, ſome that do gueſs, this Hill, that Cape.
For ſome hours our Skill in ſuſpence ſtand,
Terming this Shore, that Head-land Points the Map;
Which when miſtook, this forg'd Excuſe goes clear,
O ſuch and ſuch a Land it firſt did 'pear.

In all which ſtrife, ſtreſs'd Sailers *have the pain,*
By drudging, pulling, hawling, ſtanding to it
In Cold and Rain, both dry and wet, they ſtrain
Themſelves, and toyl; none elſe but they muſt do it.
Both Prow *and* Poop *do anſwer to the* Helm;
The Steerſman *ſings, no Grief his Joy can whelm.*

By Night our Watch we ſet, by Day our Sight,
And furl our Sails; If Pirates *do appear,*
We reſt reſolv'd; 'Tis Force make Cowards fight,
Though none more dare, than they that have moſt fear.
It's Courage *makes us raſh, and* Wiſdom *cold;*
Yet Wiſe-men ſtout, and ſtrong, grow Lion-bold.

Sapientiam Sapiens dirigit, Artes Coartifex, *&c.* *Phocylides.*

The Wiſe-man knows his Wiſdom *how to uſe,*
Th' Artificer, what Art *'tis beſt to chuſe.*
'Tis a true Saying, and approved long,
The Wiſe-man is more worthy than the Strong.
The Fields *he tills, the* City *he can guide,*
And for the Ships *in* Tempeſts *will provide.*

Geometrical Definitions.

ARTS, ſaith *Arnobius*, are not together with our *Minds* ſent out of Heaven; but all are found out on the Earth, and are in proceſs of time ſought and fairly forged by a continual Meditation. Our Minds perceiving ſome Things to happen well, while it doth imitate, attempt, and try, while it doth reform, and change, hath out of theſe ſome *Science* or *Art*, the which afterwards by Study is brought to ſome perfection.

Yet the *Practice* of *Art* is not manifeſt but by *Speculative Illuſtration:* And for this cauſe I choſe a *Speculative* Part; And firſt of *Geometry*, that you may the better know the Practice. To begin then.

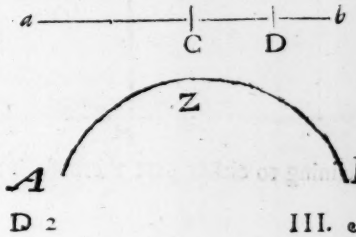
I. *A* Point *is that which hath no Part.*

A *Point* is ſuppoſed to be a Thing *indiviſible*, or that cannot be divided into Parts, being the beginning of all Dimenſion. As the Point or Prick noted with the Letter A; and is but only the Term or End of Quantity.

A

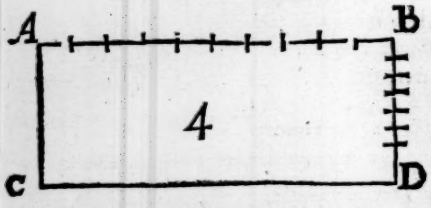
II. *A* Line *is Length, without Breadth or Thickneſs.*

A *Lines* Extremes or Bounds are two *Points*, as you may ſee in the Line *a*, *b*. A *Line* is either ſtraight or crooked. A *Line* is capable of Diviſion in Length only, and may be divided equally in the Point C, or unequally in D.



III. *A* Right Line *is the ſhorteſt of all* Lines, *drawn from any two* Points.

IV. *A* Superficies *has* Longitude *and* Latitude *only.*



A *Superficies* is that which hath only length and breadth. In the firſt kind of Magnitude the Motion of a *Point* produceth a *Line:* So in the ſecond kind of Magnitude, the Motion of a *Line* produceth a *Superficies.* This is alſo capable of two dimenſions, as the length AB and CD, and the breadth AC and BD; and may be divided into any number of Parts.

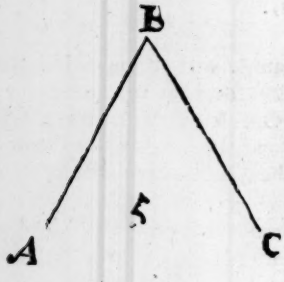
V. *The Extremes of a Superficies are* Lines.

As the Ends of a *Line* are *Points*, ſo the Bounds or Extremes of a *Superficies* are *Lines*; as the *Lines* AB, and BD, and DC, and CA.

VI. *A* Plain Superficies *lieth equally between his* Lines.

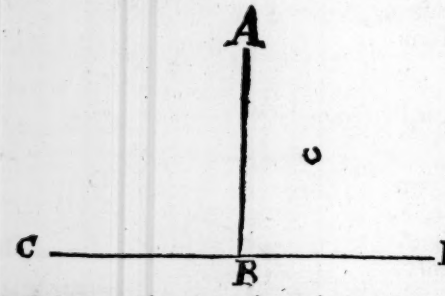
So the *Superficies* ABCD is that which lieth direct and evenly between his *Lines*, and is the ſhorteſt of all *Superficies* between the ſame *Lines.*

VII. *An* Angle *is when two* Lines *are extended in the ſame* Superficies, *ſo that they meet together in a* Point, *inclining to each other.*



As you may ſee the two *Lines* AB and BC incline one towards the other, and touch one the other, in the *Point* B. In which *Point*, by reaſon of the inclination of the ſaid *Lines*, is made the *Angle* ABC. And here note, That an *Angle* is moſt commonly ſigned by three Letters, the middlemoſt whereof ſheweth the *Angular Point*, as when we ſay the *Angle* ABC, you are to underſtand the *Angle* at B.

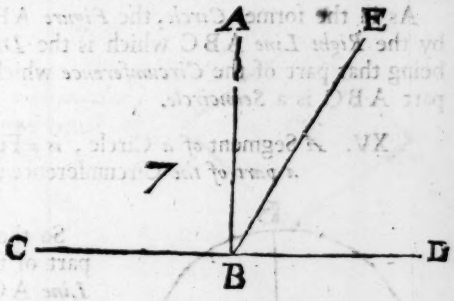
VIII. *A* Right Angle *is that which is produced of a* Right Line, *falling upon a* Right Line, *and making two equal* Angles *on each ſide.*



As upon the *Right Line* CD ſuppoſe there ſtands another *Right Line* AB, in ſuch ſort that it maketh the *Angles* on either ſide thereof equal; namely, the *Angle* ABD on the one ſide, equal to the *Angle* ABC on the other ſide; then are either of theſe *Angles*, *Right Angles*; and the *Right Line* AB, which ſtandeth erect upon the *Right Line* CD, without inclining to either part thereof, is a *Perpendicular* to the *Line* CD.

IX. *An*

IX. *An* Obtuſe Angle *is that which is greater than a* Right Angle.



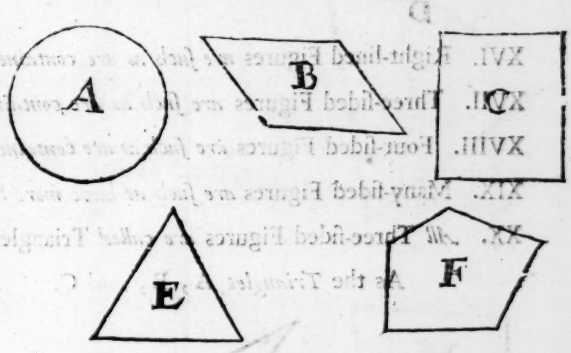
So the *Angle* CBE is an *Obtuſe Angle*, becauſe it is greater than the *Right Angle* ABC; for it doth not only contain that *Right Angle*, but the *Angle* ABE alſo, and therefore is *Obtuſe*.

X. *An* Acute Angle *is leſs than a* Right Angle.

So you may ſee the *Angle* EBD is an *Acute Angle*; for it is leſs than the *Right Angle* ABD, in which is contained the other *Acute Angle* ABE.

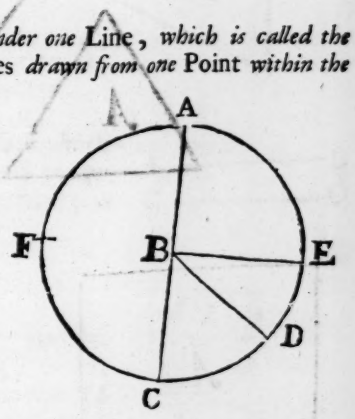
XI. *A* Figure *is that which is contained under one* Term, *or many.*

As the *Figure* A is contained under one *Limit* or *Term*, which is the *Circular Line*; alſo the *Figures* B and C are contained under four *Right Lines:* likewiſe the *Figure* E is contained under three *Right Lines*; and the *Figure* F under five *Right Lines*. And ſo of all other *Figures*.



XII. *A* Circle *is a plain* Figure *contained under one* Line, *which is called the* Circumference; *unto which all* Lines *drawn from one* Point *within the* Figure, *and falling upon the* Circumference *thereof, are equal one to the other.*

As the *Figure* AECF is a *Circle* contained under the *Crooked Line* AECD, which *Line* is called the *Circumference*. In the middle of this *Figure* is the *Point* B, from which *Point* all *Lines* drawn to the *Circumference* are equal, as the *Lines* BA, BE, BD, BC; and this *Point* B is called the *Center* of the *Circle*.



XIII. *The* Diameter *of a* Circle *is a* Right Line *drawn by the* Center *thereof, and ending at the* Circumference, *on either ſide, divides the* Circle *into two equal Parts.*

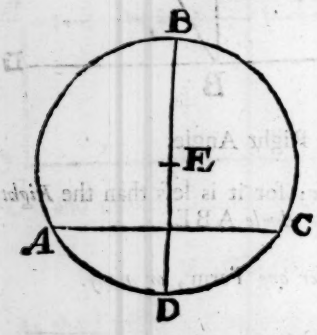
So the *Line* ABC in the former *Figure*, is the *Diameter* thereof, becauſe it paſſeth from the *Point* A on the one ſide, and paſſeth by the *Point* B, which is the *Center* of the *Circle*, and divideth the *Circle* into two equal parts, namely, AEC being on one ſide of the *Diameter*, equal to AFC on the other.

XIV. *A* Semicircle *is a* Figure *contained under the* Diameter, *and that part of the* Circumference *cut off by the* Diameter.

As

As in the former *Circle*, the *Figure* AFC is a *Semicircle*, becauſe it is contained by the *Right Line* ABC which is the *Diameter*, and by the *crooked Line* AFC, being that part of the *Circumference* which is cut off by the *Diameter*: Alſo the part ABC is a *Semicircle*.

XV. *A* Segment *of a* Circle, *is a* Figure *contained under a* Right Line, *and a part of the* Circumference, *greater or leſs than a* Semicircle.



So the *Figure* ABC, which conſiſteth of the part of the *Circumference* ABC, and the *Right Line* AC, is a *Segment* of a *Circle*, greater than a *Semicircle*.

Alſo the other *Figure* ACD, which is contained under the *Right Line* AC, and the part of the *Circumference* ADC, is a *Segment* of a *Circle* leſs than a *Semicircle*.

XVI. Right-lined Figures *are ſuch as are contained under* Right Lines.

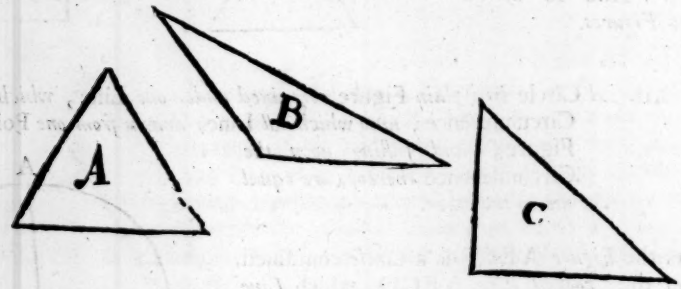
XVII. Three-ſided Figures *are ſuch as are contained under three* Right Lines.

XVIII. Four-ſided Figures *are ſuch as are contained under four* Right Lines.

XIX. Many-ſided Figures *are ſuch as have more Sides than four.*

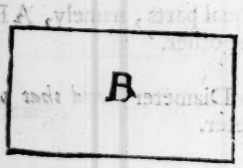
XX. *All* Three-ſided Figures *are called* Triangles:

As the *Triangles* A, B, *and* C.





XXI. Of *Four-ſided Figures*, a *Quadrat* or *Square* is that whoſe *Sides* are equal, and his *Angles* right, as the *Figure* A.



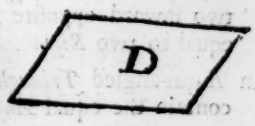
XXII. A *Long Square* is that which hath right *Angles*, but unequal *Sides*, as the *Figure* B.

XXIII. A

XXIII. A *Rhombus* is a *Figure Quadrangular*, having equal *Sides*, but not equal or right *Angles*, as the *Figure* C.



XXIV. A *Rhomboides* is a *Figure* whose oppoſite *Sides* are equal, and whoſe oppoſite *Angles* are alſo equal: but it hath neither equal *Sides*, nor right *Angles*, as the *Figure* D.

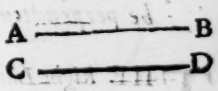




XXV. All other *Figures* of *Four Sides* are called *Trapezia's*, as *L* and *M*.



XXVI. *Parallel* or *Equi-diſtant Right Lines*, are ſuch which being in one and the ſame *Superficies*, and produced infinitely on both ſides, do never concur; as the two *Lines* A B, C D.



XXVII. A *Solid* is that which hath Length, Breadth and Thickneſs, as a *Cube* (or *Die*;) as the *Figure* I: Or a *Sphere* or *Globe*, as the *Figure* K. The bounds of a Body are *Superficies*.



Geometrical Theorems.

I. ANY two *Right Lines* croſſing one another, make the vertical *Angles* equal. *Euclid.* 15. 1.

II. If any *Right Line* fall upon two parallel *Right Lines*, it maketh the outward *Angle* of the one, equal to the inward *Angle* of the other; and the two inward oppoſite *Angles*, on contrary ſides of the falling *Line*, alſo equal. *Euclid.* 29. 1.

III. If any Side of a *Triangle* be produced, the outward *Angle* is equal to the two inward oppoſite *Angles*, and all the three *Angles* of any *Triangle* are equal to two *Right Angles*. *Euclid.* 32. 1.

IV. In Æqui-angled *Triangles* all their Sides are proportioned, as well ſuch as contain the equal *Angles*, as alſo the ſubtendent Sides. *Euclid.* 4. 6.

V. If any four *Quantities* be proportional, the firſt multiplied into the fourth, produceth a *Quantity* equal to that which is made by multiplication of the ſecond into the third. *Euclid.* 16. 6.

VI. In all Right-angled *Triangles*, the Square of the Side ſubtending the *Right Angle*, is equal to both the Squares of the containing Sides. *Euclid.* 47. 1.

VII. All *Parallelograms* are double to the *Triangles* that are deſcribed upon their *Baſis*, their *Altitudes* being equal. *Euclid.* 41. 1.

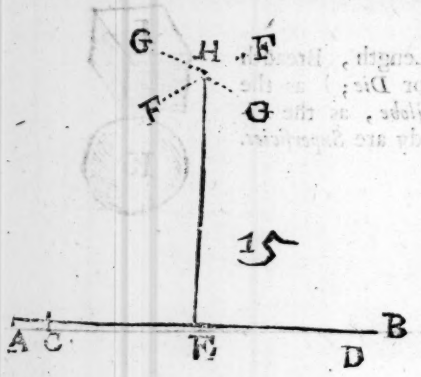
VIII. All *Triangles* that have one and the ſame *Baſe*, and lie between two *Parallel Lines*, are equal one to the other. *Euclid.* 37. 1.

Geometrical Problems.

PROBLEM I.

Upon a Right Line *given, how to erect another* Right Line, *which ſhall be perpendicular to the* Right Line *given.*

THE *Right Line* given is AB, upon which from the *Point* E it is required to erect the *Perpendicular* EH. Opening your *Compaſs* at any convenient diſtance, place one Foot in the aſſigned *Point* E, and with the other make the two Marks C and D, equidiſtant on each ſide the *Point* E; then opening your *Compaſſes* again to any other convenient diſtance more than the former, place one Foot in C, and with the other deſcribe the *Arch* GG; alſo (the *Compaſſes* remaining at the ſame diſtance) place one Foot in the *Point* D, and with the other deſcribe the *Arch* FF. Then from the *Point* where thoſe two *Arches* interſect each other, which is at H, draw the *Right Line* HE, which ſhall be *Perpendicular* to the given *Right Line* AB, which was the thing required to be done.

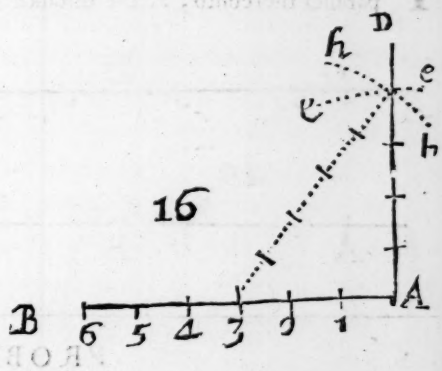


PROBL.

PROBL. II.

How to erect a Perpendicular *on the end of a* Right Line *given.*

LEt AB, be a *Line* given, and let it be required to erect the *Perpendicular* AD. First upon the *Line* AB, with your *Compaſſes* opened to any ſmall diſtance, make five ſmall Diviſions, beginning at A, noted with 1, 2, 3, 4, 5. Then take with your *Compaſſes* the diſtance from A to 4, and place one Foot in A, and with the other deſcribe the *Arch* e e: Then take the diſtance from A to 5, and placing one Foot of the *Compaſſes* in 3, with the other Foot deſcribe the *Arch* h h, cutting the former *Arch* in the *Point* D: Laſtly, from D draw the *Line* DA, which ſhall be *perpendicular* to the given *Line* AB.



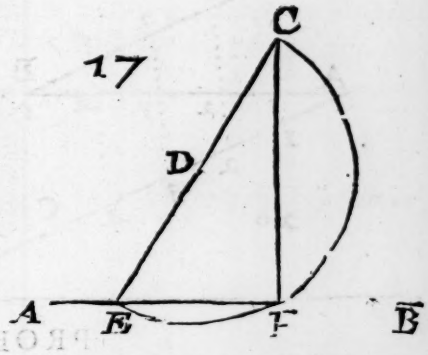
This operation is grounded upon this Concluſion, *viz.* Theſe three Numbers 3, 4, and 5, makes a Right-angled *Triangle*, which is very neceſſary in many Mechanical Operations, and eaſie to be remembred.

PROBL. III.

How to let fall a Perpendicular *from any* Point *aſſigned, upon a* Right Line *given.*

THe *Point* given is C, from which *Point* it is required to draw a *Right Line* which ſhall be *perpendicular* to the given *Right Line* AB.

Firſt from the given *Point* C, to the *Line* AB, draw a *Line* at pleaſure, as CE, which divide into two equal parts in the *Point* D. Then placing one Foot of the *Compaſſes* in in the *Point* D, with the diſtance DC, deſcribe the *Semicircle* CFE, cutting the given *Line* AB in the *Point* F. Laſtly, from the *Point* C draw the *Right Line* CF, it ſhall be a *Perpendicular* to the given *Line* AB, which was required.

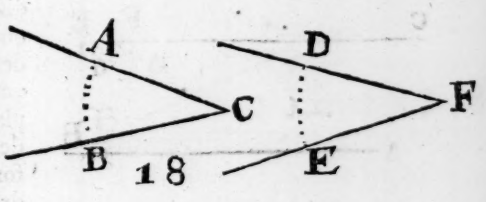


PROBL. IV.

How to make an Angle *equal to an* Angle *given.*

LEt the *Angle* given be ACB, and let it be required to make another *Angle* equal thereunto.

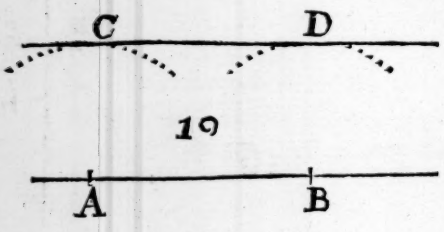
Firſt draw the *Line* FF at pleaſure; then upon the given *Angle* at C (the *Compaſſes* opened to any convenient diſtance) deſcribe the *Arch* AB; and alſo upon the *Point* F, the *Compaſſes* unaltered, deſcribe the *Arch* DE; Then take the diſtance AB, and ſet the ſame from E to D; Laſtly draw the *Line* DF. So ſhall the *Angle* DFE be equal to the given *Angle* ACB.



PROBL. V.

A Right Line *being given, how to draw another* Right Line *which ſhall be parallel to the former, at any diſtance required.*

THe *Line* given is AB, unto which it is required to draw another *Right Line* parallel thereunto, at the diſtance AC or DB.

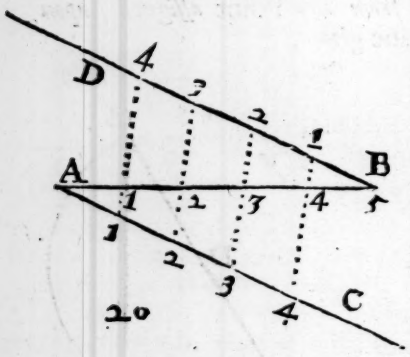


Firſt, Open your *Compaſſes* to the diſtance AC or BD; then placing one Foot in A, with the other deſcribe the *Arch* C; alſo (at that diſtance) place one Foot in B, and with the other deſcribe the *Arch* D. Laſtly, draw the *Line* CD, that it may only touch the *Arches* C and D: So ſhall the *Line* CD be parallel to the *Line* AB, and at the diſtance required.

PROBL. VI.

To divide a Right Line *into any number of equal Parts.*

LEt AB be a *Right Line* given, and let it be required to divide the ſame into five equal Parts.

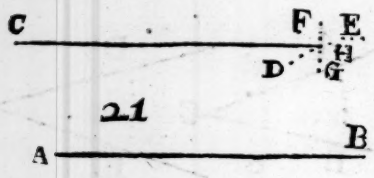


Firſt, From one end of the given *Line* AB draw the *Line* AC, making an *Angle* therewith at pleaſure. Then draw the *Line* BD, making the *Angle* ABD equal to the *Angle* CAB. Then from the *Points* A and B, ſet off upon theſe two *Lines* any number of equal Parts, being leſs by one than the Parts into which the *Line* AB is to be divided, which in this Example muſt be 4. Then draw ſmall *Lines* from 1 to 4, from 2 to 3 twice, and from 1 to 4, which *Lines* croſſing the given *Line* AB ſhall divide it into five equal Parts, as was required.

PROBL. VII.

A Right Line *being given, how to draw another* Right Line *parallel thereunto, which ſhall alſo paſs through a* Point *aſſigned.*

LEt AB be a *Line* given, and let it be required to draw another *Line* parallel thereunto, which ſhall paſs through the given *Point* C.



Firſt, Take with your *Compaſſes* the diſtance from A to C, and placing one Foot thereof at B, with the other deſcribe the *Arch* DE; then take in your *Compaſſes* the whole *Line* AB, and place one Foot in C, and with the other deſcribe the *Arch* FG, croſſing the former *Arch* in the *Point* H: Then if you draw the *Line* CH, it ſhall be parallel to AB, as was required.

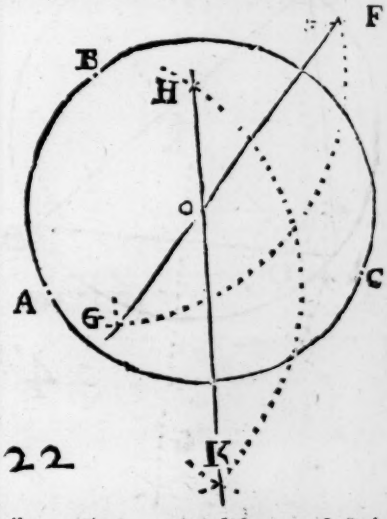
PROBL.

PROBL. VIII.

Having any three Points *given which are not ſituated in a* Right Line, *how to find the* Center *of a* Circle *which ſhall paſs through thoſe three* Points.

THe three *Points* given are A, B, and C; now it is required to find the *Center* of a *Circle* whoſe *Circumference* ſhall paſs through thoſe three *Points*.

First, Open your *Compaſſes* to any diſtance greater than half the diſtance between B and C; then place one Foot in the *Point* B, and with the other deſcribe the *Arch* FG; then the *Compaſſes* remaining at the ſame diſtance, place one Foot in the *Point* C, and with the other turn'd about make the marks F and G in the former *Arch*, and draw the *Line* FOG.



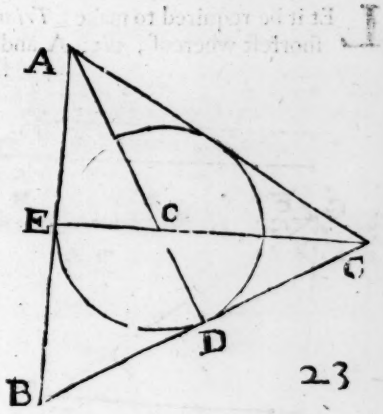
22

In like manner open your *Compaſs* at a diſtance greater than half AC; place one Foot in the *Point* A, with the other deſcribe the *Arch* HK: then the *Compaſſes* remaining at the ſame diſtance, place one Foot in the *Point* C, and turning the other about, make the marks HK in the former *Arch*. Laſtly, draw the *Right Line* HK, cutting the *Line* FG in O, ſo ſhall O be the *Center*, upon which you may deſcribe a *Circle* at the diſtance of OA, and it ſhall paſs through the three given *Points* ABC, which was required.

PROBL. IX.

How to deſcribe a Circle *in a* Triangle, *that ſhall only touch the three Sides.*

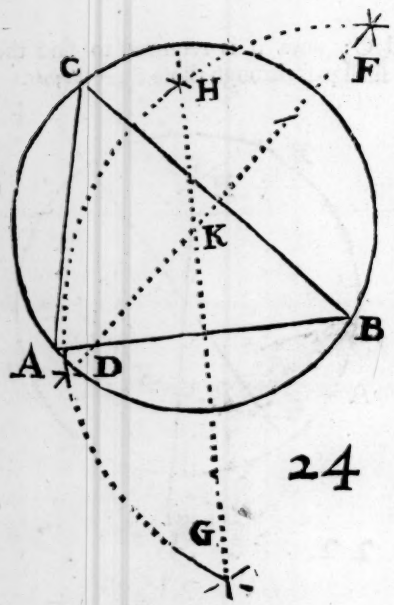
LEt the *Triangle* be ABC; then divide the Side of the *Triangle* AB in two equal parts, as at E, and draw the *Line* CE; and likewiſe divide BC equally, and draw the *Line* AD, where they croſs one the other, as at O, that is the *Center* of the *Circle*: Therefore put one Point of the *Compaſſes* in the *Center* O, and extend the other until it touch either ſide, and deſcribe the *Circle* CDF, which will only touch the Sides of the *Triangle* ABC.



23

PROBL. X.

About a given Triangle *to deſcribe a* Circle.

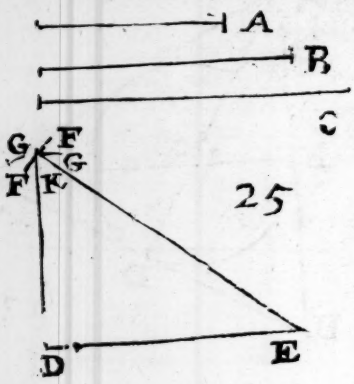


LEt the *Triangle* be ABC. This is only the eighth *Problem* in other words, that is; Through the three *Points* ABC, to deſcribe a *Circle*, and is performed as you ſee in the *Figure*.

PROBL. XI.

Any three Right Lines *being given, ſo that the two ſhorteſt together be longer than the third, To make thereof a* Triangle.

LEt it be required to make a *Triangle* of theſe three *Lines* A, B, and C, the two ſhorteſt whereof, *viz.* A and B together, are longer than the third C.



Firſt draw the *Line* DE equal to the given *Line* B; then take with your *Compaſſes* the *Line* C, and ſetting one Foot in E, with the other deſcribe the *Arch* FF: alſo take with your *Compaſſes* the given *Line* A, and placing one Foot in D, with the other deſcribe the *Arch* GG, cutting the former *Arch* in the *Point* K. Laſtly, from the *Point* K draw the *Lines* KE and KD, which ſhall conſtitute the *Triangle* KDE, whoſe *Sides* ſhall be equal to the three given *Lines* A, B, C.

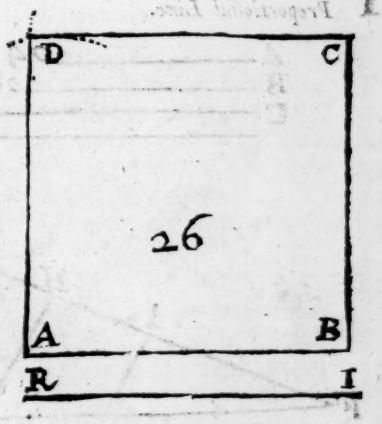
PROBL.

PROBL. XII.

Having a Right Line *given, How to make a* Geometrical Square, *whoſe* Sides *ſhall be equal to the* Right Line *given.*

THe *Line* given is RI, and it is required to make a *Geometrical Square* whoſe *Sides* ſhall be equal to the *Line* RI.

Firſt draw the *Line* AB equal to the given *Line* RI, then (by the ſecond *Problem*) upon the *Point* B raiſe the *Perpendicular* BC, making the *Line* BC equal to the given *Line* RI; then taking the ſaid RI in your *Compaſſes*, place one Foot in C, with the other deſcribe an *Arch* at D; and the *Compaſſes* being at the ſame diſtance, ſet one Foot in A, and croſs the former *Arch* at D; then draw the *Lines* DC and DA, which ſhall conclude the *Geometrical Square* ABCD, which was required.



PROBL. XIII.

Two Right Lines *being given, How to find a third which ſhall be proportional unto them.*

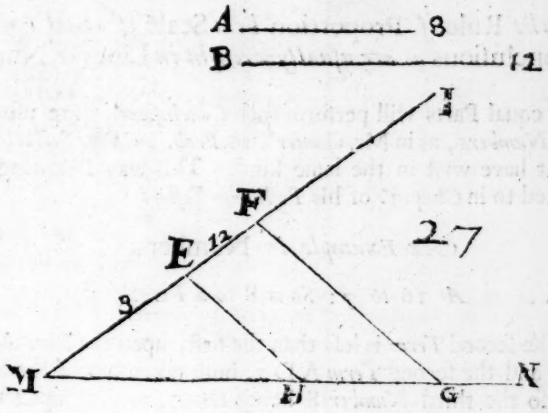
LEt the given *Lines* be A and B; and it is required to find a third *Line* which ſhall be proportional unto them.

Firſt draw two *Right Lines*, making any *Angle* at pleaſure, as the *Lines* LM and MN, making the *Angle* LMN: Then take the *Line* A in your *Compaſſes*, and ſet the length thereof from M to E; alſo take the *Line* B, and ſet the length thereof from M to F, and alſo from M to H: then draw the *Right Line* EH, and from the *Point* F draw the *Line* FG parallel to EH: So ſhall MG be the third Proportional required: Arithmetically ſay,

As ME *to* MH: *So is* MF *to* MG 18.
8 12 12

12
24
12
144

6(0
x44 (18
88

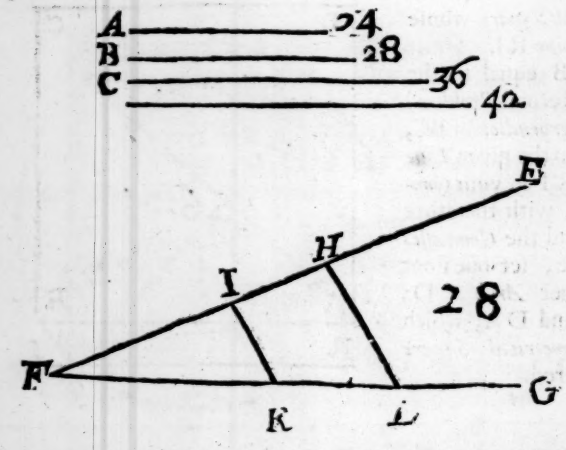


PROBL.

PROBL. XIV.

Three Right Lines *being given, To find a fourth in proportion to them.*

THe three *Lines* given are A, B, C, unto which it is required to find a fourth *Proportional Line.*



This is to perform the Rule of Three. As in the laſt *Problem*, you muſt draw two *Right Lines*, making any *Angle* at pleaſure, as the *Angle* EFG; then take the *Line* A in your *Compaſs*, and ſet it from F to I; then take the *Line* B in your *Compaſſes*, and ſet that from F to K, drawing the *Line* IK, then take the third given *Line* in your *Compaſſes*, and ſet that from F to H, and from the *Point* H draw the *Line* HL, parallel to IK: So ſhall the *Line* FL be the fourth *Proportional* required.

Note, That theſe *Lines* are taken off a *Scale*, that is divided into 20 parts to an Inch: To do it Arithmetically, ſay,

As FI *is to* FK: *So is* FH *to* FL.
24 28 36 42

28
24 288
1008 (42 72
144 1008
2

Here note, That in performance of the laſt *Problem*, the firſt and third *Terms*, namely the *Lines* A and C, are ſet upon one and the ſame *Line*, as here upon the *Line* FE, and the ſecond *Line* B upon the other *Line* FG, upon which *Line* alſo the fourth *Proportional* will be found.

PROBL. XV.

How to work the Rule *of* Proportion *by a* Scale *of equal Parts, and ſuch other* Concluſions *as are uſually wrought in* Lines *or* Numbers.

THe *Scale* of equal Parts will perform ſuch *Concluſions* as are uſually wrought in *Lines* or *Numbers*, as in Mr. *Gunter*'s 10 *Prob.* 2 *Chap. Sector*, may be ſeen, and in others that have writ in the ſame kind. This way following Mr. *Samuel Foſter* hath directed to in *Chap.* 1. of his *Poſthuma Foſteri.*

An Example in Numbers.

As 16 *to* 7: *So is* 8 *to a Fourth.*

Here becauſe the ſecond *Term* is leſs than the firſt, upon the *Line* AB, I ſet AC the firſt *Term* 16, and the ſecond *Term* AD 7, both taken out of the *Scale* of equal Parts: thence alſo the third *Number* 8 being taken, with it upon the *Center* C,

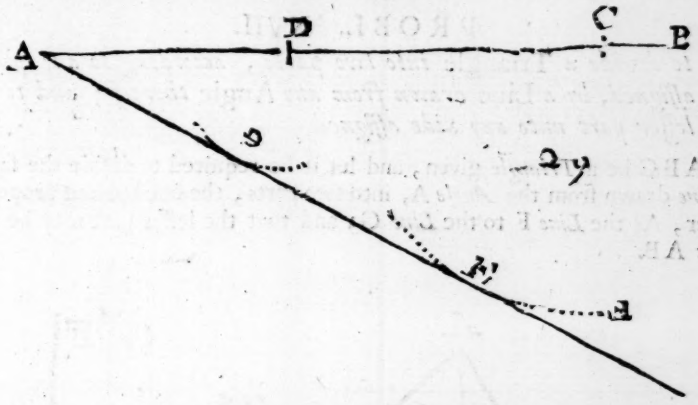
I deſcribe the *Arch* EF, and from A draw the *Line* AE, which may only touch the ſame *Arch*; then from D, I take DG, the leaſt diſtance from the *Line* AE, and the ſame meaſured in the ſame *Scale* of equal Parts, gives $3\frac{1}{2}$, the fourth *Term* required.

But if the ſecond *Term* ſhall be greater than the firſt, then the form of working muſt be changed, as in the following *Example.*

EXAMPLE.

As 7 to 16: So 21 to a Fourth.

Upon the *Line* AB, I ſet the ſecond *Term* 16, which is here ſuppoſed to be AD; then with the firſt *Term* 7 upon the *Center* D, I deſcribe the *Arch* GH, and draw the *Line* AG that may juſt touch it: Again, having taken 21 out of the ſame *Scale*, I ſet one Foot of that Extent upon the *Line* AB, removing it until the other Foot being turned about, will juſtly touch the *Line* AG before-drawn; and where it reſteth, I make the *Point* C; then meaſuring AC upon your *Scale*, you ſhall find it 48 Parts, which is the fourth *Number* required.



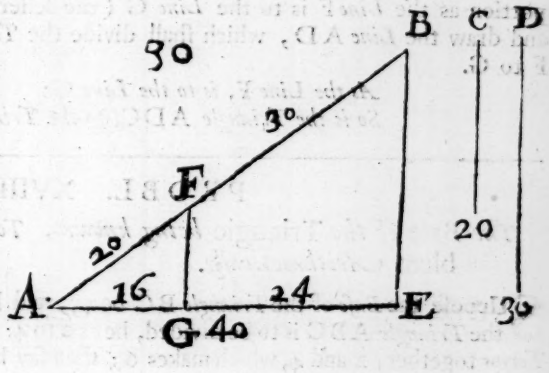
I have been the more large upon this, becauſe in the following Treatiſe I ſhall quote ſome other places in *Poſthuma Foſteri:* and the Solution of *Proportions* muſt be referred thither, the form of their Operations being the ſame with this.

PROBL. XVI.

To divide a Right Line *given, into two parts, which ſhall have ſuch proportion one to the other as two given* Right Lines.

THe *Line* given is AE, and it is required to divide the ſame into two parts, which ſhall have ſuch proportion one to the other, as the *Line* C hath to the *Line* D.

Firſt, From the *Point* A draw a *Right Line* at pleaſure, making the *Angle* BAE; then take in your *Compaſſes* the *Line* C, and ſet it from A to F; and alſo take the *Line* D, and ſet it from F to B, and draw the *Line* BE: Then from the *Point* F draw the *Line* FG, parallel to BE, cutting the given *Line* AE in the *Point* G: So is the *Line* AB divided into two parts in the *Point* G, in proportion to each other, as the *Line* C is to the *Line* D.



Arithme-

Arithmetically, Let the *Line* A E contain 40 Perches or Foot, and let the *Line* C be 20, and the *Line* D 30 Perches; and let it be required to divide the *Line* A E into two parts, being in proportion one to the other, as the *Line* C is to the *Line* D.

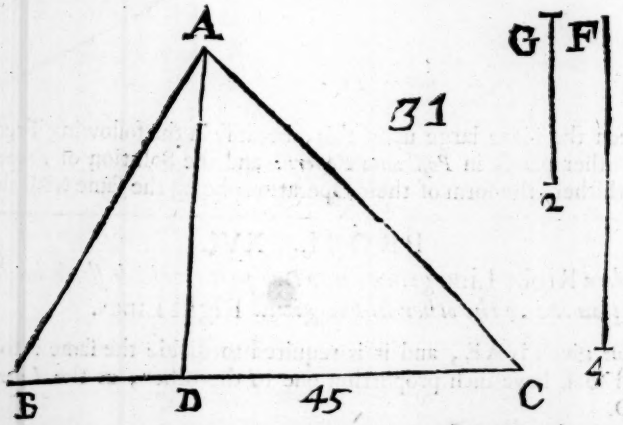
First, Add the *Lines* C and D together, their Sum is 50: Then ſay by the *Rule* of *Proportion*, If 50 give 40, the whole *Line* A E; What ſhall 30 the greater given *Term* give? Multiply and divide, and you ſhall have in the Quotient 24 for the greater part of the *Line* A E; which being taken from 40, there remains 16 for the other part A G: For,

As A B *is to* A E:	*So is* B F *to* E G.
50 40	30 24.
	40
28	00
x2ꝺꝺ (24	120
55ꝺ	1200

PROBL. XVII.

How to divide a Triangle *into two parts, according to any proportion aſſigned, by a* Line *drawn from any* Angle *thereof; and to lay the leſſer part unto any Side aſſigned.*

LEt A B C be a *Triangle* given, and let it be required to divide the ſame by a *Line* drawn from the *Angle* A, into two parts, the one bearing proportion to the other, As the *Line* F to the *Line* G; and that the leſſer part may be towards the Side A B.



By the laſt *Problem* divide the *Baſe* of the *Triangle* B C in the *Point* D, in proportion as the *Line* F is to the *Line* G (the leſſer part being ſet from B to D,) and draw the *Line* A D, which ſhall divide the *Triangle* A B C in proportion as F to G.

As the Line F, *is to the Line* G:
So is the Triangle A D C, *to the Triangle* A B D.

PROBL. XVIII.

The Baſe *of the* Triangle *being known, To perform the foregoing* Problem *Arithmetically.*

SUppoſe the *Baſe* of the *Triangle* B C be 45, and let the Proportion into which the *Triangle* A B C is to be divided, be as 2 to 4. Firſt add the two proportional *Terms* together, 2 and 4, which makes 6; then ſay by the *Rule* of *Proportion*, If 6, the Sum of the Proportional *Terms*, give 45 (the whole *Baſe* B C,) What ſhall 4 the greater

greater *Term* given? Multiply and divide, and the Quotient will give you 30, for the greater *Segment* of the *Baſe* DC, which being deducted from the whole *Baſe* 45, there will remain 15 for the leſſer *Segment* BD.

As 6 is to 45: So is 4 to 30.

$$\frac{4}{180}$$

PROBL. XIX.

How to divide a Triangle *whoſe* Area *or* Content *is known, into two Parts, by a* Line *drawn from an* Angle *aſſigned, according to any Proportion required.*

LEt the *Triangle* ABC contain 9 *Acres*, and let it be required to divide the ſame into two Parts, by a *Line* drawn from the *Angle* A, the one to contain 5 *Acres*, and the other 4 *Acres*. Firſt, meaſure the whole length of the *Baſe*, which ſuppoſe 45; Then ſay, If 9 *Acres* the quantity of the whole *Triangle*, give 45 the whole *Baſe*, What parts of the *Baſe* ſhall 4 *Acres* give? Multiply and divide, the Quotient will be 20 for the leſſer *Segment* of the *Baſe* BD; then draw the *Line* AD, which ſhall divide the *Triangle* ABC according to the proportion required.

If 9 Acres give 45, What ſhall 4 Acres give?

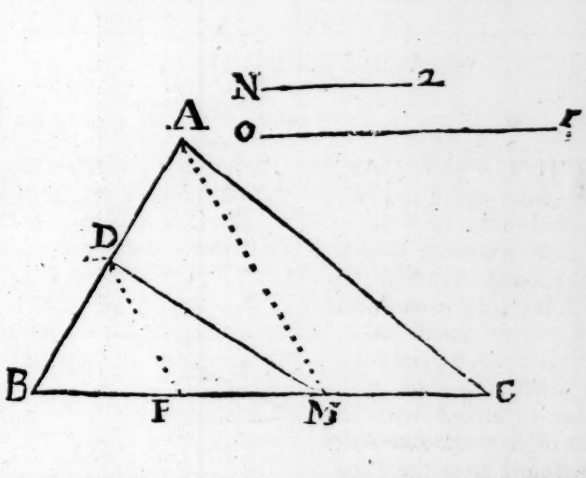
Anſwer 20

$$\frac{4}{180}$$

PROBL. XX.

How to divide a Triangle *given into two parts, according to any Proportion aſſigned, by a* Line *drawn from a* Point *given in any of the Sides thereof; and to lay the greater or leſſer part towards any* Angle *aſſigned.*

THe *Triangle* given is ABC, and it is required from the *Point* M to draw a *Line* that ſhall divide the *Triangle* into two parts, being in proportion one to the other, as the *Line* N is to the *Line* O; and to lay the leſſer part towards B.



Firſt, from the limited *Point* M draw a *Line* to the oppoſite *Angle* at A; then divide the *Baſe* BC in proportion as O to N, which Point of Diviſion will be at F; then draw FD parallel to AM: Laſtly, from D draw the *Line* DM, which will divide the *Triangle* into two parts, being in Proportion one to the other, as the *Line* O is to the *Line* N.

PROBL. XXI.

To perform the foregoing Problem *Arithmetically.*

IT is required to divide the *Triangle* ABC, from the *Point* M, into two parts in proportion as 5 to 2.

First, divide the *Base* BC according to the given Proportion; then becauſe the leſſer Part is to be laid towards B, meaſure the diſtance from M to B, which ſuppoſe 32: Then ſay by the *Rule* of *Proportion*, If MB 32, give FB 16, what ſhall AB 28 give? Multiply and divide, the Quotient will be BD 14; then from D draw the *Line* DM, which ſhall divide the *Triangle* according to the required Proportion.

PROBL. XXII.

How to divide a Triangle, *whoſe* Area *or* Content *is known, into two Parts, by a* Line *drawn from a* Point *limited, in any Side thereof, according to any number of* Acres, Roods, *and* Perches.

IN the foregoing *Triangle* ABC, whoſe *Area* or *Content* is 5 *Acres* 1 *Rood*, let the limited *Point* be M in the *Baſe* thereof; and let it be required from the *Point* M to draw a *Line* which ſhall divide the *Triangle* into two parts between *Johnſon* and *Powell*, ſo as *Johnſon* may have 3 *Acres* 3 *Roods* thereof, and *Powell* may have 1 *Acre* and 2 *Roods* thereof.

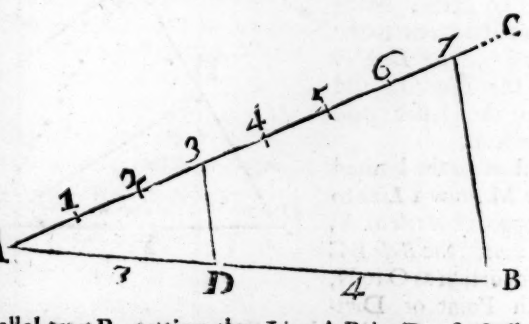
Reduce the quantities aſſigned to each of them into *Perches*, ſo *Johnſon* hath 600, and *Powell* 240 *Perches*; then you are only to perform the foregoing *Problem*, that is, to divide a given *Triangle* from a *Point* aſſigned in one of the *Sides*, into two Parts in proportion to each other, as 600 to 240, or as 5 to 2.

160	160
80	3
230	480
	120
	600

PROBL. XXIII.

From a Line *given, to cut off any Parts required.*

THe *Line* given is AB, from which it is required to cut off $\frac{3}{7}$ Parts.



First, draw the *Line* AC, making any *Angle*, as CAB; then from A ſet off 7 equal Parts, as 1, 2, 3, 4, 5, 6, 7; and from 7 draw the *Line* 7B. Now becauſe $\frac{3}{7}$ is to be cut off from the *Line* AB, therefore from the *Point* 3, draw the *Line* 3D, parallel to 7B, cutting the *Line* AB in D; ſo ſhall AD be the $\frac{3}{7}$ of the *Line* AB, and DB ſhall be $\frac{4}{7}$ of the ſame *Line*.

As A7 *is to* AB: *So is* A3 *to* AD.

PROBL.

PROBL. XXIV.

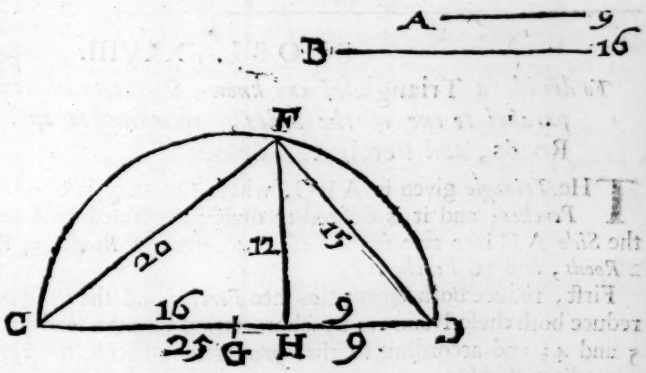
To find a Mean Proportional *between two* Lines *given.*

IN the following *Figure*, let the two *Lines* given be A and B, between which it is required to find a *Mean Proportional.* Let the two *Lines* A and B be joyned together in the *Point* E, making one *Right Line* as CD, which is divided into two equal Parts in the *Point* G; upon which *Point* G, with the diſtance GC or GD, deſcribe the *Semicircle* CFD; then from the *Point* E raiſe the *Perpendicular* EF: So ſhall the *Line* EF be a *Mean Proportional* between the two given *Lines* A and B. For, *As* ED *is to* EF: *So* EF *to* CF.

9 12 12 16

PROBL. XXV.

How to find two Lines, *which together ſhall be equal in Power to any* Line *given; And in Power the one to the other, according to any Proportion aſſigned.*



IN this *Figure*, let it be required to find two *Lines* equal in Power to AC, and in Power to each other, as A to B.

Firſt, divide the *Line* CD in the *Point* E, in proportion as A to B, (by *Prob.* 16.) then divide the *Line* CD into two equal Parts in the *Point* G, and on G, at the diſtance GD or GC, deſcribe the *Semicircle* CFD, and upon the *Point* E raiſe the *Perpendicular* EF, cutting the *Semicircle* in F. Laſtly, draw the *Lines* CF and DF, which together in Power will be equal to the Power of the given *Line* CD; and yet in Power one to the other, as A to B.

PROBL. XXVI.

How to divide a Triangle *according to any Proportion given, by a* Line *drawn parallel to one of the* Sides *given.*

THe following *Triangle* ABC is given, and it is required to divide the ſame into two Parts, by a *Line* drawn parallel to the *Side* AC, which ſhall be in proportion one to the other, as the *Line* I is to the *Line* K.

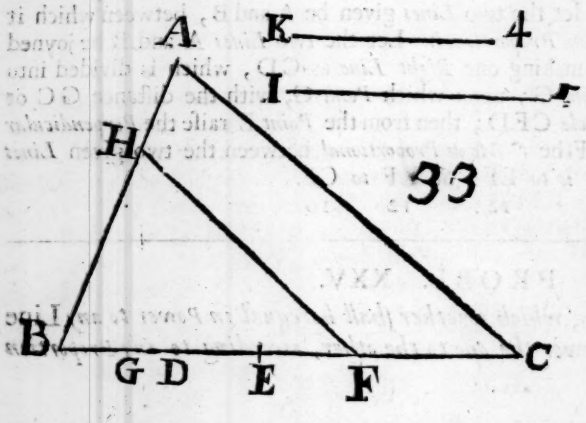
Firſt (by *Probl.* 16.) divide the *Line* BC in E, in proportion as I to K; then (by *Probl.* 24.) find a mean Proportional between BE and BC, which let be BF, from which *Point* F draw the *Line* FH, parallel to AC, which *Line* ſhall divide the *Triangle* into two parts, *viz.* the *Trapezia* AHFC, and the *Triangle* HFB, which are in proportion one to the other, as the *Line* I is to the *Line* K.

PROBL. XXVII.

To perform the foregoing Problem *Arithmetically.*

LEt the *Triangle* be ABC, and let it be required to divide the ſame into two parts, which ſhall be in proportion one to the other, as 4 to 5, by a *Line* drawn parallel to one of the *Sides.*

First, let the *Base* BC, containing 54, be divided according to the proportion given; ſo ſhall the leſſer *Segment* BE contain 24, and the greater EC 30; Then find out a mean Proportional between BE 24, and the whole *Base* BC 54, by multiplying 54 by 24, whoſe Product will be 1296; the Square Root thereof is 36, the mean Proportional ſought, which is BF. Then from the *Point* F, draw the *Line* FH parallel to AC, which ſhall divide the *Triangle*, as was required.



PROBL. XXVIII.

To divide a Triangle *of any known Quantity into two Parts, by a* Line *parallel to one of the Sides, according to any Number of* Acres, Roods, *and* Perches.

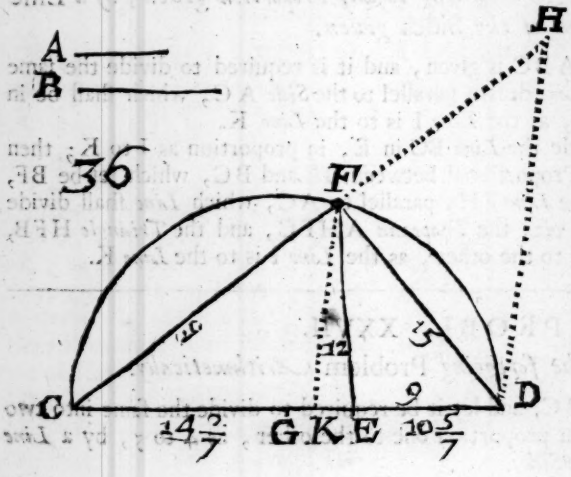
THe *Triangle* given is ABC, whoſe Quantity is 8 *Acres*, 0 *Roods*, and 16 *Perches*; and it is deſired to divide the ſame by a *Line* drawn up parallel to the *Side* AC into two parts, *viz.* 4 *Acres*, 2 *Roods*, 0 *Perches*; and 3 *Acres*, 2 *Roods*, and 16 *Perches*.

Firſt, reduce both Quantities into *Perches* and they will be 720, and 576; then reduce both theſe Numbers by abbreviation into the leaſt proportional *Terms*, viz. 5 and 4; and according to that proportion, divide the *Triangle* ABC, by the preceding *Problem*.

PROBL. XXIX.

How to divide a Line *in Power according to any Proportion given.*

IN this *Figure*, let it be required to divide the *Line* CD in Power as A to B. Firſt, divide the *Line* CD in the *Point* E, in proportion as A to B: Then divide the *Line* CD in two equal Parts in the *Point* G, and upon G as a *Center*, at the diſtance GD, deſcribe the *Semicircle* CFD, and on E raiſe the *Perpendicular* of EF, cutting the *Semicircle* in F: Then draw the *Lines* CF and DF, and produce the *Line* CF to H, till FH be equal to FD, and draw the *Line* DH. Laſtly, draw the *Line* FK, parallel to DH: Then ſhall the *Line* CD be divided in K; ſo that the *Square* of CK ſhall be to the *Square* of KD, as EC to ED, or as B to A.



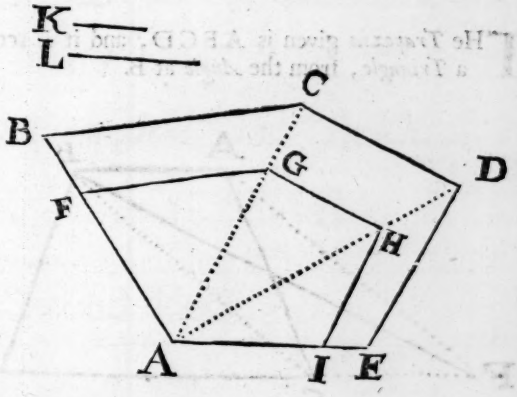
PROBL.

PROBL. XXX.

To diminiſh a Plot *given, according to any Proportion required.*

LEt ABCDE be a *Plot* given, to be diminiſhed in Power as L to K.

Divide one of the *Sides*, as AB in Power as L to K, in the *Point* F, then from the *Angle* A draw *Lines* to the *Points* C and D. That done, by F draw a *Parallel* to BC, cutting AC in G, as FG: again, from G draw a *Parallel* to DC, cutting AD in H. *Laſtly*, from H draw a *Parallel* to DE, cutting AE in I: So ſhall the *Plot* AFGHI be like ABCDE, and in proportion to it, as the *Line* L to the *Line* K, which was required.

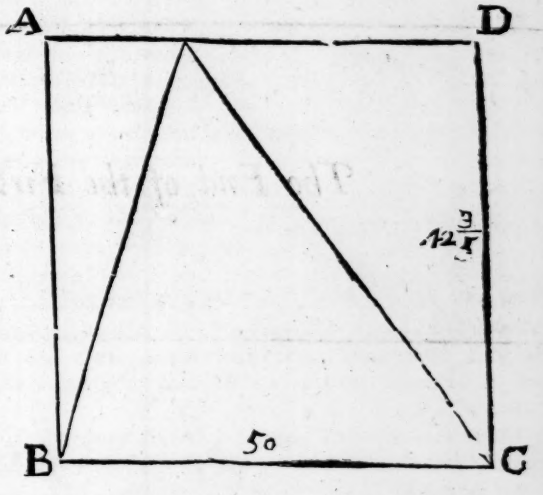


PROBL. XXXI.

How to make a Triangle *which ſhall contain any Number of* Acres, Roods, *and* Perches, *and whoſe* Baſe *ſhall be equal to any (poſſible)* Number *given.*

LEt it be required to make a *Triangle* which ſhall contain 6 *Acres*, 2 *Roods*, 25 *Perches*, whoſe *Baſe* ſhall contain 50 *Perches*. You muſt firſt reduce your 6 *Acres*, 2 *Roods*, and 25 *Perches*, into *Perches*, which makes 1065.

Now to make a *Triangle* that ſhall contain 1065 *Perches*, and whoſe *Baſe* ſhall be 50 *Perches*, do thus; double the number of *Perches* given, namely 1065, and they make 2130; then becauſe the *Baſe* of the *Triangle* muſt contain 50 *Perches*, divide 2130 by 50, the Quotient will be $42\frac{3}{5}$ which will be the length of the *Perpendicular* of the *Triangle*. This done, from any *Scale* of equal Parts, lay down the *Line* BC equal to 50 *Perches*; then upon G raiſe the *Perpendicular* GE, equal to $42\frac{3}{5}$ *Perches*, and draw the *Line* AD, parallel to BC; then from any *Point* in the *Line* AD, as from C, draw the *Line* BC, and GC, including the *Triangle* BGC, which ſhall contain 6 *Acres*, 2 *Roods*, 25 *Perches*, which was required.

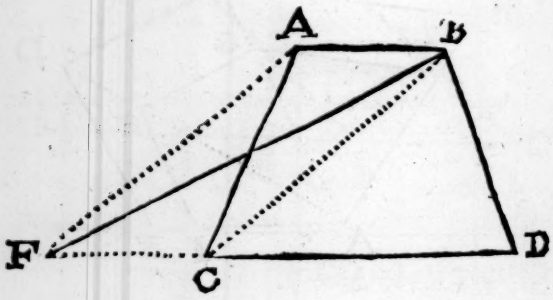


PROBL.

PROBL. XXXII.

How to reduce a Trapezia *into a* Triangle, *by a* Line *drawn from any* Angle *thereof.*

THe *Trapezia* given is ABCD, and it is required to reduce the ſame into a *Triangle*, from the *Angle* at B.



Firſt, extend the *Line* DC, and draw the *Diagonal* BC; then from the *Point* A draw the *Line* AF, parallel to CB, extending it till it cut the *Side* DC in the *Point* F. Laſtly, from the *Point* B draw the *Line* BF, conſtituting the *Triangle* FBD, which ſhall be equal to the *Trapezia* ABCD.

And ſo I have concluded what I did intend of *Geometrical Problems:* neither had I gone ſo far, in regard Mr. *William Leybourn* hath ingeniouſly and very fully ſhown them in his Firſt Book of his *Compleat Surveyor*; but no Book (as I remember) now extant of *Navigation*, hath the foregoing *Problems* ſo large: Beſides, I ſhall direct the *Mariner* to Survey any *Plantation* or Parcel of Land very eaſily, by his *Sea-Compaſs*.

The End of the Firſt Book.

THE

Mariners Magazine:

OR,

Sturmy's *Mathematical and Practical* ARTS.

The Second Book.

The Argument.

You're come to see a Sight, *the* World's *the* Stage;
Perhaps you'l say, 'Tis a Star-gazing Age.
Come out and see the Use of Instrument,
Can Speculation *yield you such Content?*
That you can rest in learning *but the* Name,
Of flying Pegasus, *or swift* Charles-Wain?
And would you learn to know how he doth move
About his Axis, *set at work by* Jove?
If you would learn the Practice, *read, and then*
I need not thus intreat you by my Pen,
To tread in Arts *fair Steps, or gain the way;*
Go on, make haste, Delinquent, *do not stay.*
Or will you scale Olympick *Hills so high?*
Be sure take fast hold on Astronomy;
Then in that fair-spread Canopy no Way
From thee is hid, no not Galaxia.
They that descend the Water's deep, do see
Our great God's Wonders *there, and what they be.*
They that contemplate on the Starry Sky,
Do see the Works *that he hath fram'd so high.*
Then learn the Worlds Division, *and that* Art
Which I shall shew you in this Second Part.

IN this *Book* is contained the Description, Making, and Use of the most necessary *Instruments* belonging to the Art of *Navigation*; As the *Mathematical Ruler*, on which are these *Scales* following; *viz.* The *Line* of *Chords, Points, Leagues, Longitude, Natural Sines, Tangents, Secants*, at one End; at the other are *Dialling Scales*, *viz.* The *Chords* and *Gnomon Line*, and *Scale* of Six Hours; *Scale* of Inclination of *Meridians*, and two *Scales* for enlarging the *Hour-Lines*, upon any reclining, inclining, or declining Plain without a *Center*, called the greater and lesser *Pole*: On the other side are a *Line* of *Artificial Sines, Tangents*, and *Numbers*; A *Meridian Line*, according to Mr. *Edward Wright*'s Projection; And *Tables* for the making of these *Scales*, with a *Line* of *Longitude* and *Reduction*; Also a useful *Travis-Scale*, with a *Table* for to make it, with Artificial *Rhombs* for *Points*, *Halves*, and *Quarters*. Also the making of the *Sinical Quadrant*, and

and ſo ordered, that by the help of an *Index*, and *Lines* thereon, it ſhall anſwer many uſeful Queſtions in *Aſtronomy* and *Navigation*. Alſo the making the plain *Sea-Chard*, and the true *Sea-Chard*, and particular *Charts* for any Place; with the moſt uſeful and neceſſary *Semicircle*, that will protract any *Courſe* upon any *Chard*, without drawing *Rhomb-lines* to fill the *Chard*; that ſo, by help of this *Inſtrument*, the *Chard* may ſerve for many Voyages. Alſo the Making and Uſe of a *Compleat Inſtrument*, on the back-ſide of a *Nocturnal*, with 31 of the moſt noted *Fixed Stars*; which ſheweth the Hour of the Night that any *Star* cometh to the *Meridian*, with his Declination *N.* or *S.* Alſo a *Table* of the *Declination*, *Right Aſcenſion*, *Latitude*, and *Longitude* from *Tycho*'s *Tables*, rectified for the year 1671. On the other ſide a *Nocturnal* ſo ordered, that it ſhall give you the Hour of the Night by the *North-Star* and brighteſt *Guard*, and his bearing from the *Pole*, whereby you may take the *Declination*; and it likewiſe ſheweth the *Suns* place in the *Ecliptick* every day in the year; likewiſe the Making and the Uſe of the *Croſs-ſtaff*, *Back-ſtaff*, and *Quadrant*. Likewiſe a *Kalendar* ſhewing the *Prime*, *Epact*, and *Dominical Letter*, with a *Table* of the *Suns Declination*, and the uſe thereof.

A Deſcription of INSTRUMENTS.

CHAP. I.

Of Inſtruments *in general.*

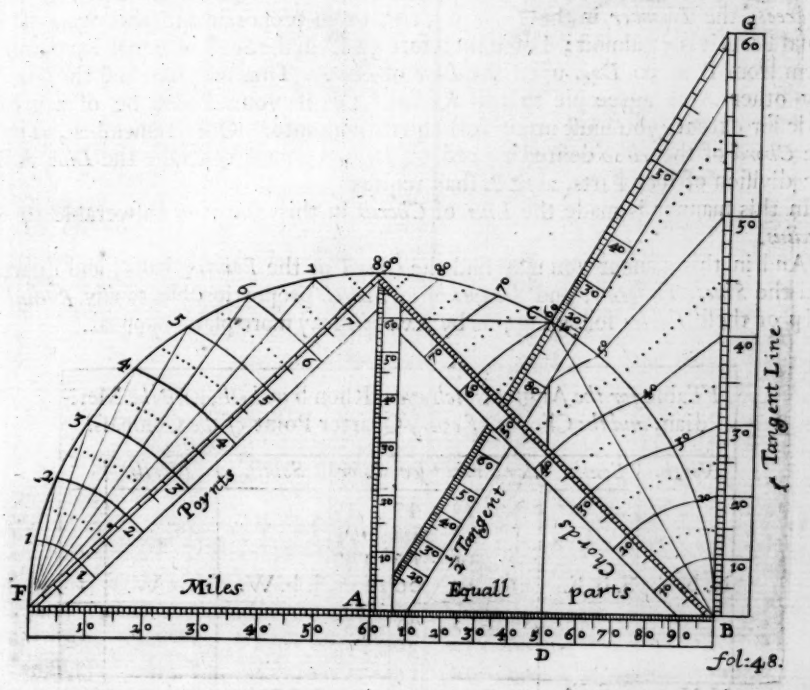
THe particular Deſcription of the ſeveral *Inſtruments* that have from time to time been invented for *Mathematical Practice*, would make a *Treatiſe* of it ſelf; and in this place it is not ſo neceſſary to be inſiſted on. To omit therefore the Deſcription of unneceſſary *Inſtruments*, I ſhall immediately begin with the Deſcription of thoſe which are the Grounds and Foundation of all the reſt, and are now the only *Inſtruments* in eſteem amongſt *Navigators* and *Mariners* at *Sea*, which are chiefly theſe; *viz.* The *Mathematical Ruler*, the *Plain Scale*, the *Sinical Quadrant*, the *Plain Sea-Chard*, and the *True Sea-Chard*, the particular *Chard*, the *Semicircle* or *Protractor*, the *Nocturnal*, the *Croſs-Staff*, *Back-Staff*, and *Quadrant*. Now as I would not confine any Man to the Uſe of any particular *Inſtrument*; ſo I would adviſe every Man not to incumber himſelf with Multiplicity, ſince theſe aforeſaid are ſufficient for all Occaſions. Theſe *Inſtruments* have been largely deſcribed already by divers; as namely, by Mr. *Blundevil*, Mr. *Wright*, Mr. *Gunter*, and others: but ſome not fitted with *Tables* for the making of them. Therefore in this place it will be very neceſſary to give a particular Deſcription of them, and ſo if any Man hath a deſire to any particular *Inſtrument*, he may give the better direction for the making thereof, or be able to make it himſelf.

Foraſmuch as there is a continual uſe both of *Scales* and *Chords*, which are on the *Mathematical Scale*, in drawing of *Schemes* in the Art of *Navigation*, and other Sciences in this *Treatiſe*; Therefore we will give the *Diagram* of the *Mathematical Scale*, that *Mariners* may underſtand the making of them, which is commendable in an expert *Mariner*. I could wiſh that all *Maſters* and *Mates* were able to make their own *Inſtruments*, that if they ſhould be long at *Sea*, and by diſaſter break or loſe their *Inſtruments*, they may be able to make more themſelves.

For the inſcription of the *Chords*, *Sines*, *Tangents*, and *Secants*, the *Semidiameter* AB muſt be divided into 100, 1000, 10000, or 100000 equal parts; and then by the

Table

Table of *Natural Sines*, *Tangents*, *Secants*, *Chords*, and *Points*, which I have fitted on purpoſe for this Work. Theſe *Lines* are eaſily divided, as is ſhewn hereafter.



Here followeth a *Table* of *Chords* to every *Degree* of the *Quadrant*. He that deſires it larger, may make it to the Parts of a *Degree*. The *Chord* is the *Natural Sine* of half the *Arch* doubled.

For *Example*, If you double the *Natural Line* of 6. 15. 25. 30 *Deg.* you ſhall produce the *Chords* of 12. 30. 50. 60 *Degrees*; thus 1045 is the *Sine* of 6 *Degrees*, being doubled, the Sum will be 2090 the *Chord* of 12 *Degrees*; and ſo of the reſt, as in the *Table* following.

The Table *of* Chords.

De	Chord	De	Chord	De	Chord	De	Chord	De	Chord	De	Chord
01	17	16	278	31	534	46	781	61	1015	76	1231
02	35	17	296	32	551	47	797	62	1030	77	1245
03	52	18	313	33	568	48	813	63	1045	78	1259
04	70	19	330	34	585	49	830	64	1060	79	1273
05	87	20	347	35	601	50	845	65	1074	80	1286
06	105	21	364	36	618	51	861	66	1089	81	1299
07	122	22	382	37	635	52	876	67	1104	82	1312
08	139	23	398	38	651	53	892	68	1118	83	1325
09	157	24	416	39	668	54	908	69	1133	84	1338
10	175	25	432	40	684	55	923	70	1147	85	1351
11	192	26	450	41	700	56	939	71	1161	86	1364
12	209	27	466	42	717	57	954	72	1176	87	1377
13	226	28	484	43	733	58	670	73	1190	88	1389
14	244	29	501	44	749	59	984	74	1204	89	1402
15	261	30	518	45	765	60	1000	75	1217	90	1414

This done, Proportion the *Radius* of a *Circle* to what extent you pleaſe; make A B equal thereto, which muſt be divided into equal Parts, as before directed, and and by this *Table*, the *Chord* of any *Arch* proportionable to this *Radius*, may ſpeedily be obtained. As for *Example*, Let there be required the *Chord* of *Thirty Degrees*, the *Number* in the *Table* is 510; or in proportion to this *Scale* of 100 equal Parts it is 52 almoſt; I take therefore 52 from the *Scale* of equal Parts, and ſet them from B to 30 *Deg.* upon the *Line* of *Chords*. Thus may you find the *Chord* of any other *Arch* agreeable to this *Radius*. Or if your *Radius* be of a greater or leſſer extent, you muſt make A B equal thereunto. Only remember, That if the *Chord* of the *Arch* deſired exceed 60 *Deg.* you muſt continue the *Line* A B in the diviſion of ſuch Parts, as need ſhall require.

In this manner is made the *Line* of *Chords* in this *Diagram* anſwerable to that *Radius*.

And in this manner you may find the *Chord* of the *Points*, halfs, and quarters, and the *Sines*, *Tangents*, and *Secants* of any *Arch* proportionable to any *Radius*, by help of theſe *Tables* following; as by *Example* may more plainly appear.

A Table *for the* Angles *which every* Rhomb *maketh, with the* Meridian, *and the* Chords *of every* Quarter Point *of the* Compaſs.

North.	*South.*	*deg.*	*mi.*	*ſec.*	*Chor.*	*South.*	*North.*	
		2	48	45	49			
		5	37	30	98			
		8	26	15	147			
N. b. E.	S. b. E.	11	15	00	195	S. b. W.	N. b. W.	1
		14	3	45	244			
		16	52	30	293			
		19	41	15	333			
N. N. E.	S. S. E.	22	30	00	390	S. S. W.	N. N. W.	2
		25	18	45	427			
		28	7	30	485			
		30	56	15	533			
N. E. b. N.	S. E. b. S.	33	45	00	580	S. W. b. S.	N. W. b. N.	3
		36	33	45	627			
		39	22	30	673			
		42	11	15	720			
N. E.	S. E.	45	00	00	767	S. W.	N. W.	4
		47	48	40	811			
		50	37	30	855			
		53	26	15	899			
N. E. b. E.	S. E. b. E.	56	15	00	942	S. W. b. W	N. W. b. W	5
		59	3	45	985			
		61	52	30	1028			
		64	41	15	1069			
E. N. E.	E. S. E.	67	30	00	1111	W. S. W.	W. N. W.	6
		70	18	45	1151			
		73	7	30	1190			
		75	56	15	1230			
E. b. N.	E. b. S.	78	45	00	1268	W. b. S.	W. b. N.	7
		81	33	45	1305			
		84	22	30	1343			
		87	11	15	1378			
East.	East.	90	00	00	1414	West.	West.	8

Let there be required the *Chord* of the firſt *Point* on the *Scale*, 11 *Deg.* 15, in this *Table*.

The

The *Numbers* anſwering to 11 *Deg.* 15 *Min.* is 195; I take therefore with my *Compaſſes* 19, (or reckon ſo many on the *Scale* of Equal parts, which is joyned with a *Line* intended to be made; and ſo with a *Square* for that purpoſe, as ſhall be ſhewed) mark from F towards 8 the firſt *Point* 11 *Deg.* 15, the *Radius* of the *Circle* being AB; and ſo of the reſt.

Of the Line *of* Longitude.

THe *Line* of *Longitude* is divided by help of this *Table*, the uſe of which is very eaſie; for in the firſt, third and fifth *Columns* are the *Minutes* of *Longitude*, on the *Line* of *Longitude*; and in the ſecond, fourth, and ſixth the *Chords* in *Degrees* and *Minutes*, againſt which the *Minutes* of *Longitude* are to be divided: Therefore having divided a *Line* of *Chords* to 90, you may divide the *Line* of *Longitude* thereby.

Examp. 1 *Minute* of *Longitude* is againſt 89 *d.* 02 *d.* on the *Chords*, 2 *Minutes* againſt 88 *d.* 6 *m.* 3 *Minutes* againſt 87 *d.* 8 *m.* and ſo of the reſt.

The uſe of this *Scale* is to find how many *Minutes* of the *Equinoctial*, make a *Degree* of *Longitude* in any *Parallel* of *Latitude*.

Examp. In the *Latitude* of 40 *Degrees*, how many *Minutes* (or *Miles*) make 1 *Degree* of *Longitude?* Extend your *Compaſſes* on the *Line* of *Chords* from the beginning of the *Degrees* to 40 *Deg.* that extent ſhall reach from 60 *Min.* on the *Line* of *Longitude*, to 46 *Min.* and ſo many *Minutes* make a *Degree* of Longitude in that *Latitude*.

A Table *to divide the* Line *of* Longitudes.

M	Chords.		M	Chords.		M	Chords.	
1	89	02	21	69	30	41	46	54
2	88	06	22	68	29	42	45	35
3	87	8	23	67	28	43	44	12
4	86	11	24	66	25	44	42	49
5	85	14	25	65	23	45	41	26
6	84	16	26	64	20	46	40	00
7	83	18	27	63	15	47	38	28
8	82	20	28	62	11	48	36	54
9	81	22	29	61	06	49	35	16
10	80	24	30	60	00	50	33	34
11	79	26	31	58	53	51	31	45
12	78	27	32	57	46	52	29	58
13	77	29	33	56	38	53	27	59
14	76	30	34	55	29	54	25	53
15	75	31	35	54	18	55	23	33
16	74	31	36	53	09	56	21	06
17	73	32	37	51	56	57	18	13
18	72	32	38	50	42	58	14	50
19	71	32	39	49	26	59	10	26
20	70	31	40	48	11	60	00	00

SINES.

A *Sine* is a *Right Line*, falling from the end of an *Arch* perpendicular to the *Diameter*, which is drawn to the other end of the *Arch*; ſo CD is a *Sine* of 60 *Degrees*. By this *Table* of *Natural Sines*, to every *Degree* of the *Quadrant* which I have fitted for this purpoſe, whoſe *Radius* is 1000, you ſhall find the *Sine* of 60 *deg.* to be 866. I take therefore with my *Compaſſes* 86 from my *Scale* of *Equal Parts*, and ſet them from A towards 8 in the *Line* of *Sines* for 60 *Degrees*, where

A Table *of* Natural Sines *to the* Radius *of* 1000.

De	Sines.	De	Sines.	De	Sines.	De	Sines.	De	Sines.	De	Sines.
1	17	16	276	31	515	46	719	61	875	76	970
2	35	17	292	32	530	47	731	62	883	77	974
3	52	18	309	33	545	48	743	63	891	78	978
4	70	19	326	34	559	49	755	64	899	79	982
5	87	20	342	35	574	50	766	65	906	80	985
6	105	21	358	36	588	51	777	66	914	81	988
7	122	22	375	37	602	52	788	67	921	82	990
8	139	23	391	38	616	53	799	68	927	83	993
9	156	24	407	39	629	54	809	69	934	84	995
10	174	25	423	40	643	55	819	70	940	85	996
11	191	26	438	41	656	56	829	71	946	86	998
12	200	27	454	42	669	57	839	72	951	87	999
13	225	28	469	43	682	58	848	73	956	88	999
14	242	29	485	44	695	59	857	74	961	89	000
15	259	30	500	45	707	60	866	75	966	90	1000

 where

where the *Radius* of the *Circle* is AB, and the *Number* in the *Table* answering 30 *Degrees* is 500; take therefore with your *Compasses* 50 equal Parts of AB, and lay it from A upon the *Line* of *Sines* for 30; and so of the rest.

TANGENTS.

A Table *of* Natural Tangents *to every* Degree *of the* Quadrant.

De	Tang.	De	Tang.	De	Tang.	De	Tang.	De	Tangents.
1	17	19	344	37	754	55	1428	73	3271
2	35	20	364	38	781	56	1483	74	3487
3	52	21	384	39	810	57	1540	75	3732
4	70	22	404	40	839	58	1600	76	4011
5	87	23	424	41	869	59	1664	77	4331
6	105	24	445	42	900	60	1732	78	4705
7	123	25	466	43	933	61	1804	79	5145
8	141	26	488	44	966	62	1881	80	5671
9	158	27	510	45	1000	63	1963	81	6314
10	176	28	532	46	1036	64	2050	82	7115
11	194	29	554	47	1072	65	2145	83	8144
12	213	30	577	48	1110	66	2246	84	9514
13	231	31	601	49	1150	67	2356	85	11430
14	249	32	625	50	1132	68	2475	86	14301
15	268	33	649	51	1285	69	2605	87	19081
16	287	34	675	52	1290	70	2747	88	28636
17	306	35	700	53	1327	71	2904	89	57290
18	325	36	727	54	1377	72	3078	90	*Infinite.*

A *Tangent* is a *Right Line* touching the *Circle*, and is limited by the *Secant*; as BG in the *Diagram*, which is the *Tangent* of the *Arch* BC 60 *Degrees*; and in the *Table* of *Tangents* you shall find it to be 1732 equal Parts; therefore take with your *Compasses* 173 Parts, and that will reach from B to G, the *Tangent* of 60 *Degrees* in the *Scale*, and the *Tangent* 30 *Degrees* is 577 Parts; therefore take 57 Parts, it will reach from B to the length of 30 *Degrees*; and so of the rest.

SECANTS.

A Table *of* Secants *to every* Degree *of the* Quadrant.

De	Sec.	De	Sec.	De	Sec.	De	Sec.	De	Secants.
1	1000	19	1058	37	1252	55	1743	73	3420
2	1001	20	1064	38	1269	56	1788	74	3628
3	1001	21	1071	39	1287	57	1836	75	3864
4	1002	22	1078	40	1305	58	1887	76	4133
5	1004	23	1086	41	1325	59	1942	77	4445
6	1005	24	1095	42	1346	60	2000	78	4810
7	1007	25	1103	43	1367	61	2063	79	5241
8	1010	26	1113	44	1390	62	2130	80	5759
8	1012	27	1123	45	1414	63	2203	81	6392
10	1015	28	1132	46	1439	64	2281	82	7185
11	1019	29	1143	47	1466	65	2366	83	8205
12	1022	30	1155	48	1494	66	2458	84	9567
13	1026	31	1167	49	1524	77	2559	85	11474
14	1031	32	1179	50	1556	68	2669	86	14335
15	1035	33	1192	51	1589	69	2790	87	19107
16	1040	34	1206	52	1624	70	2924	88	28654
17	1046	35	1221	53	1662	71	3071	89	57299
18	1051	36	1236	54	1701	72	3236	99	*Infinite.*

A *Secant* is a *Line* drawn from the *Center* of the *Circle*, until it meet with the *Tangent Line*; as AG in the foregoing *Diagram* cuts the *Tangent* of the *Arch* BC 60 *Degrees* in G: so the *Secant* of 60 *Degrees*, in this *Table* of *Secants* is found 2000 equal Parts; therefore take off 200, it shall reach from A to G for the *Secant* of 60 *Degrees*, and the *Secant* of 30 *Degrees* in this *Table* is found to be 1154; therefore take with your *Compasses* 115 equal Parts, and it shall reach from A towards G for the *Secant* of 30 *Degrees*, as you may find by the *Scale* in the *Diagram*.

Versed

Verſed SINES.

A *Verſed Sine* is found by ſubtracting the *Sine Complement* out of the *Radius*. *Example.* For to know the *Verſed Sine* of 60 *Degrees*, you muſt ſubtract the *Sine* of 30 *Degrees*, *viz.* 500 out of the *Radius* 1000, or *Sine* of 90, AB, the remain will be DB 500, for the *Verſed Sine* of the *Arch* BC 60 *Degrees*. In like manner the *Verſed Sine* of 30 *Degrees* is 134; and ſo work in like manner for any other *Degree*.

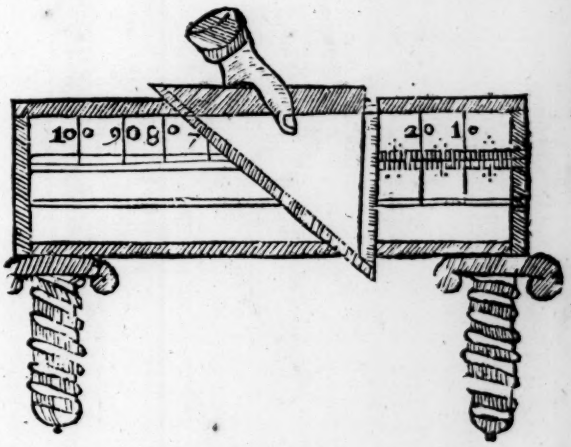
CHAP. II.

A Deſcription *of what* Inſtruments *of* Braſs, Steel, Iron, *and* Wood, *you muſt be provided with before you can make* Inſtruments *for* Mathematical Uſes.

BEfore we explain the other part of the *Diagram* it will be neceſſary for to give a Deſcription of what *Inſtruments* in *Braſs*, *Steel*, *Iron*, or *Wood*, you muſt have by you in readineſs, before you can make a *Mathematical Inſtrument*; That Men that are ingenious may be provided in ſome meaſure with ſuch, before they go to *Sea*, to ſpend their ſpare time on this *Practice*. In brief, they are theſe.

Firſt, For *Inſtruments* of *Wood*, you muſt be provided with ſeveral *Scales* of *Equal Parts*, of different lengths, according to the *Radius* of thoſe *Lines* you intend to divide. You muſt be fitted with ſome pieces of *Box*, dry, clean from Knots, ſtraight, and ſmooth planed, or other *Wood*, on which you may make what *Scale* you pleaſe. You muſt have by you a *Square* of *Braſs* and *Wood*, ſuch as you may ſee in this *Figure*, with a pair of *Cramps* made of *Iron*, with *Screws* to faſten the *Scale* of *Equal Parts*, to the *Scale* to be made, ſo as they may not ſlip. Or for ſmall *Scales*, you may faſten the *Scale* of *Equal Parts*, and the *Scale* to be made by it, on a piece of *Deal Board*, with the Heads of *Scuper Nails*, ſo as they may not ſtir; but for greater *Inſtruments*, *Croſs-ſtaves*, and *Gauging-rods*, you muſt divide them as in this *Figure*. You muſt have a *Gauge* made of *Braſs*, with a good *Steel Pin*, for the drawing of ſtraight *Lines* on your *Scale*, for the diviſion of the *Columns* for Graduation. You muſt have two or three Sorts and Sets of *Steel Letters* and *Figures*, and *Figures* for Ornament, with a neat *Hammer* to uſe with them: And the *Figures*, *Letters*, and *Ornament-Figures*, ſet in an *Alphabet-Box*, with written *Letters* and *Figures* before them, for the ready finding of them; with *Characters* of the *Signs*, *Planets*, and *Stars*.

Scales of equal parts



Scales of Box or other Wood.

2 Squares.

2 Cramps.

Scales faſtened with Nails, on Deal-Boards.

A Braſs Gauge.

Steel Letters and Figures.

The

Gauging Inſtruments.

Braſs Compaſſes, together with an Arch and four Points, to take in and out.

The uſe

A pair of Dividers.

Beam-Compaſſes.

Hand-Vice.

Files.

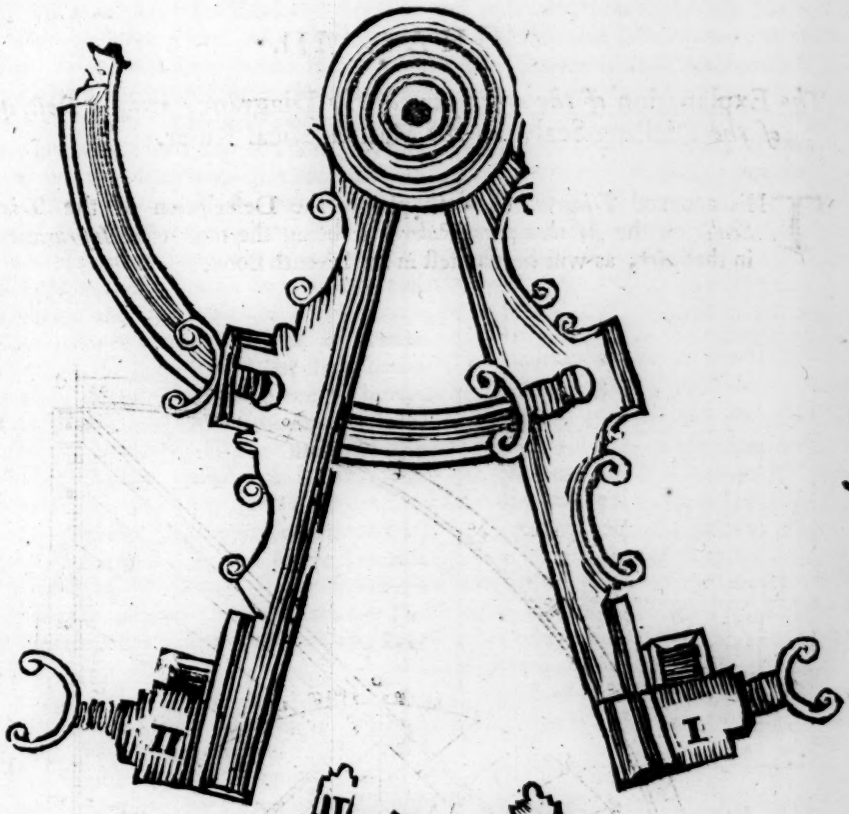
To ſet off the Inſtrument.

The *Inſtrument* that you divide with, the Edge muſt be very thin and ſharp, and you may have ſeveral of them; or the end of a *Pen-knife* may do for a ſhift. You muſt have a *Braſs* pair of *Compaſſes* to go with an *Arch* and *Screws*, to faſten at any diſtance; and four *Steel Points* to take in and out; two long *Points* for to reach a great diſtance, and two other ſhort *Points*; one is to be made round for a *Center-Point*, that it may not go too far into the *Wood*; and the other pointed like a *Dutch* Knife, and the Shoulder fitted ſquare to be faſtned, and taken in and out at pleaſure. The Uſe of theſe *Points* is to draw *Circles* on round *Inſtruments*, as *Nocturnals*, and the like. You may have two pair of *Dividers*, the leaſt three Inches and a half, and the biggeſt ſeven Inches and a half long. I hold them beſt that are made with a Bow at the Head, and to be ſet together by a Screw in the midſt. Be ſure they be made of good *Steel*. Theſe are to divide equal Parts, or any other equal Diviſion. You muſt have for great *Inſtruments*, as *Bows*, *Quadrants*, and the like, a pair of *Beam-Compaſſes*, for to ſweep the *Arches* of them. You ſhould have a *Hand-Vice*, ſo made as to ſcrew into the edge of a *Board* for your uſe, and to take out again; with three or four ſorts of ſmall *Files*, for to file and make *Pins*, which you will have occaſion for.

And now I have ſhewn the *Practitioner* what *Inſtruments* he muſt be furniſhed with, I will return to the Explanation of the other part of the *Diagram* of the *Mathematical Ruler*. I had almoſt forgot a *Receit* for ſetting off the *Graduation* divided on *Box-Inſtruments*, which is this.

Take *Charcoal*, and beat it to a fine Powder, and temper it with *Linſeed-Oyl*; and let it be rubb'd on the *Inſtrument* newly divided, and lie ſo on it for a time, until it be pretty dry; and then with ſome *Sallet-Oyl* rub the *Inſtrument*, and make it clean. So will you have the *Graduation* and *Figures* ſet off very neatly on *Box Inſtruments*, with Black.

The Figure of the Foure Poynted Compasses



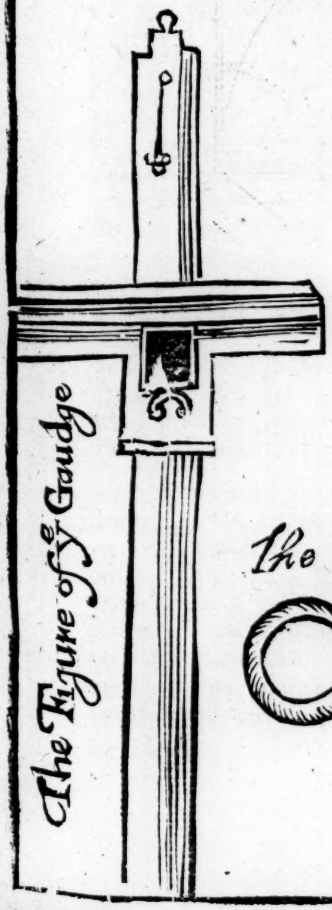
The Long Poins



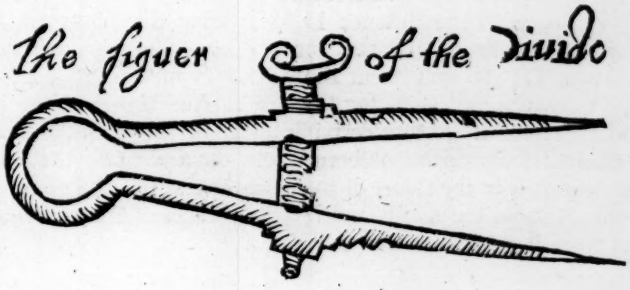
The short Poins



The Figure of ye Gaudge



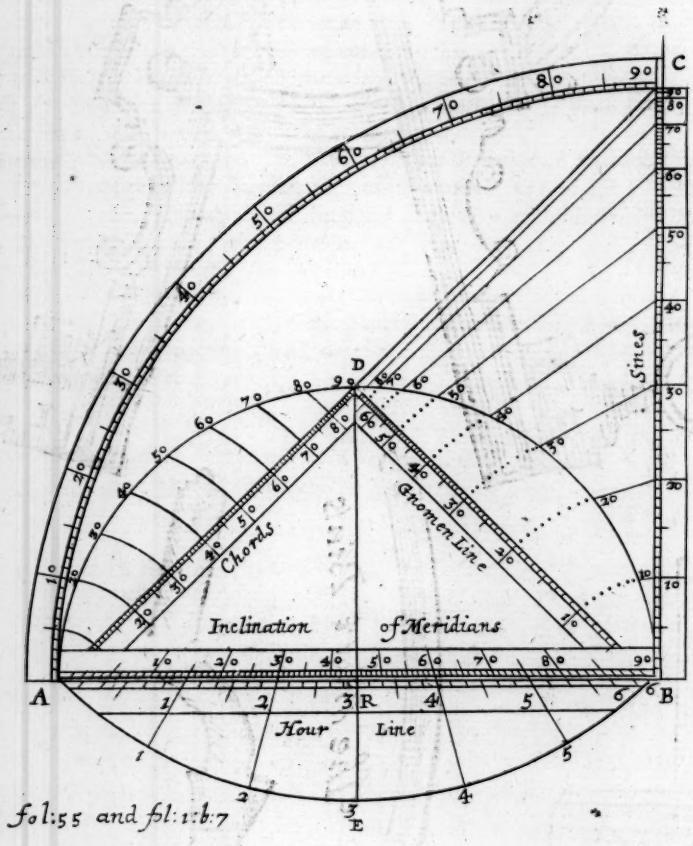
The figuer of the Divido



CHAP. III.

The Explanation *of the other part of the* Diagram, *being a Deſcription of the* Dialling-Scales *on the* Mathematical Ruler.

THis annexed *Diagram* ſheweth plainly the Deſcription of the *Dialling-Scales* on the *Mathematical Ruler*; it being the moſt eaſie *Inſtrument* uſed in that *Art*, as will be manifeſt in the Seventh Book.



fol:55 and fol:1:b:7

How to make the Diagram.

FIrſt, make a *Semicircle* by a leſs *Radius*, as ADB, and upon the midſt of the *Arch* at D, with the diſtance DA deſcribe the *Quadrant* AEB, which muſt be divided into ſix equal Parts, for ſix *Hours*; and from each *Point* draw *Lines* to the *Center* at D; So will it cut the *Line* AB in 1, 2, 3, 4, 5, 6, for the *Hour-Lines* upon the ſaid *Scale* for *Dialling*: And thus you ſee it is a *Tangent Line*, and therefore it is more certainly done by this *Table* of *Natural Tangents* for three *Hours*, if you do but obſerve where the *Right Line* DE cuts the *Tangent Line* AB, which is in the *Center* of the *Semicircle* at R; therefore you muſt begin to make this *Scale* in the midſt, and lay the diſtance of Parts anſwering the *Hours* both ways from R towards B and A.

As,

As, for *Example*, To Graduate 2 *Hours* and 4 *Hours*, you ſee in the *Table*, the *Number* anſwering to 2 *Hours* and 4 *Hours* in the firſt and laſt *Columns*, is in the third 15 *Degrees*, and in the fourth *Column* the *Tangent* is 268; therefore if you take 268 ſuch Parts whereof the *Semidiameter* R B is divided into 1000, as was ſhewed in the former *Diagram*, and put one Foot of the *Compaſſes* with that extent at R (the midſt or 3 *Hours*,) and turn the other toward B, it will make the diſtance of 4 *Hours*; and turn that diſtance towards A, it will be 2 *Hours* of the *Scale*: and ſo do with the reſt of the *Hours* and *Minutes*.

A Table *for the dividing of the* Hours *and* Minutes *upon the* Dialling-Scale.

Ho.	*M*	*D.*	*M.*	*Tangents.*	*M*	*Ho.*
3	10	2	30	44	50	
	20	5	00	87	40	
	30	7	30	132	30	
	40	10	00	176	20	
	50	12	30	222	10	
4	60	15	00	268	60	2
	10	17	30	315	50	
	20	20	00	364	40	
	30	22	30	414	30	
	40	25	00	466	20	
	50	27	30	520	10	
5	60	30	00	577	60	1
	10	32	30	637	50	
	20	35	00	700	40	
	30	37	30	767	30	
	40	40	00	839	20	
	50	42	30	916	10	
6	60	45	00	1000	00	0

In like manner for the *Scale* of *Inclination* of *Meridians*, you muſt take out the *Tangent* out of the *Table* of *Tangents* to every *Degree*, and Graduate in the ſame manner as before, from the *Center* which is the midſt of the *Scale* at 45 *Degrees*, as is plain in the *Diagram*.

For the *Gnomon-Line*, or as others call it, the *Line* of *Latitude*, let BA be the *Semidiameter*; and on B deſcribe the *Quadrant* A B C, whoſe *Arch* A C divide into 90 *Degrees*, from whence you may project the *Line* of *Sines* B C.

Now from each *Degree* of thoſe *Sines*, draw *Lines* toward the *Center* of them at A, and note where they cut the *Arch* of the *Quadrant* B D; then from B, take the diſtance of each of theſe *Interſections*, and lay them on the *Line* B D: So ſhall you have the Diviſion of the *Gnomon-Line*, or *Line* of *Latitude*.

A Table *of* Latitudes *for* Dialling.

D.	*Par.*	*D.*	*Par.*	*D.*	*Par.*	*D.*	*Par.*	*D.*	*Par.*	*D.*	*Par*
		80	991	60	926	45	816	30	632	15	354
		78	989	59	920	44	807	29	617	14	332
		76	985	58	915	43	797	28	601	13	310
		74	980	57	909	42	787	27	585	12	288
		72	974	56	903	41	776	26	568	11	263
90	1000	70	968	55	896	40	765	25	551	10	242
89	1000	69	965	54	889	39	753	24	533	9	219
88	1000	68	961	53	882	38	741	23	515	8	195
87	999	67	958	52	875	37	729	22	496	7	171
86	999	66	954	51	868	36	717	21	477	6	147
85	998	65	950	50	860	35	704	20	458	5	123
84	998	64	945	49	852	34	690	19	438	4	98
83	997	63	941	48	844	33	676	18	418	3	74
82	995	62	936	47	835	32	662	17	397	2	49
81	994	61	931	46	826	31	647	16	376	1	25

For the more ready making of this *Scale*, here is a *Table* of *Latitudes* calculated to the 90 *Degrees* of the *Quadrant*, and the way to calculate it your ſelf. As for *Example*, To find the *Parts* for 30 *Degrees* of *Latitude*,

Firſt, Find the *Sine* thereof in the *Natural Table* of *Sines*, which will be found to be 50000; which ſought for in the *Table* of *Tangents*, giveth an *Arch* of 26 *Deg.* 34. *Min.* Then the Proportion will hold,

As the Radius ---------- 100000
To the Secant 45 Deg. ---------- 141421
So is the Sine *of* 26 Deg. 34 Min. -- 44724
Unto the Parts *for the* Lat. -------- 63249

Which anſwers to the *Radius* 100000: But in my *Table* the *Parts* 632 anſwer to the *Radius* 1000, which will be ſufficient for the Graduating the *Line* of *Gnomons* or *Latitude*.

And to make 30 *Degrees* of *Latitude* on your *Scale*, you must take off 632 such Parts as the *Line* BD is divided into 1000, as you have been shewn in the former *Diagram*.

How to make the *Line* of *Chords*, you have been fully instructed already in the former *Figure*; which is only by dividing the *Arch* of the *Quadrant* AD into 90 equal parts; and from A take the distance, and lay them down in a straight *Line* AD: So shall you have the *Line* of *Chords*: Or you may do it by the *Table* of *Chords*, as before-directed.

How to make the two *Lines* or *Scales* of Inlarging *Hour-Lines* upon any reclining *Plain*, without a *Center*, called (by me) the greater and the lesser *Pole*.

Here you have a *Table* ready fitted for the making thereof.

First, You must make choice of the length of this *Scale*, that is in Proportion to the former *Lines* of the *Scale*.

A Table *of* Tangents *for* 5 Hours *to every* 5 Minutes *of an* Hour, *for inlarging the* Hour-Lines.

Ho.	M	D.	M.	Tang.	Ho.	M	D.	M.	Tang.
	5	1	15	22		5	46	15	1044
	10	1	30	44		10	47	30	1091
	15	3	45	65		15	48	45	1140
	20	5	00	87		20	50	00	1192
	25	6	15	109		25	51	15	1246
	30	7	30	132		30	52	30	1303
	35	8	45	154		35	53	45	1364
	40	10	00	176		40	55	00	1428
	45	11	15	199		45	56	15	1497
	50	12	30	222		50	57	30	1570
	55	13	45	245		55	58	45	1648
1	60	15	00	268	4	60	60	00	1732
	5	16	15	291		5	61	15	1823
	10	17	30	315		10	62	30	1921
	15	18	45	339		15	63	45	2028
	20	20	00	364		20	65	00	2044
	25	21	15	389		25	66	15	2273
	30	22	30	414		30	67	30	2414
	35	23	45	440		35	68	45	2571
	40	25	00	466		40	70	00	2748
	45	26	15	493		45	71	15	2946
	50	27	30	520		50	72	30	3171
	55	28	45	549		55	73	45	3431
2	60	30	00	577	5	60	75	00	3732
	5	31	15	607					
	10	32	30	637					
	15	33	45	668					
	20	35	00	700					
	25	36	15	733					
	30	37	30	767					
	35	38	45	802					
	40	40	00	839					
	45	41	15	877					
	50	42	30	916					
	55	43	45	957					
3	60	45	00	1000					

The first 3 *Hours* must be divided into 10 parts, and each of them into 10 more, as you have been shewn. You must have two of these *Lines* of *Equal Parts*, of two proportionable Lengths, for the greater and lesser *Pole*; and so take of the *Tangent-parts* answerable to every 5 *Minutes* of an *Hour*: As you see the first and second *Columns* of the *Table* are *Hours* and *Minutes*, the third *Degrees* and *Minutes*, and the fourth *Tangents*. So the *Tangent* of the first 2 *Hours* of the *Scale* or 30 *Degrees*, is 577 *Parts*; take of your two *Scales* 57 *Parts*; first, of the largest *Radius* for 2 *Hours* on the greater *Scale*, and the like number of the smaller *Radius* (or *Line* of *Equal Parts*) for two *Hours* of the lesser *Scale*. And so in the same manner you must work to finish the whole *Scales* of what *Radius* you please, by these *Tables*, as hath been directed.

The Use hereof is fully shewn in the Seventh Book of the *Art of Dialling*.

These *Scales* are sufficient to make any sort of *Dials*, in any *Latitude* (as is there shewn) with great ease.

There are two *Lines*, called by the Names of *Style* and *Substyle*; but they are only for one *Latitude*, but may be found for any. But the *Scales* before-explained are most useful, and do the same thing, as you will find in the *Art of Dialling*. And these are the *Scales* on one Side of the *Ruler*.

CHAP.

CHAP. IV.

The Scales *or* Lines *on the Back-side of the* Mathematical Ruler, *are these:* *A* Line *of* Numbers, *A* Line *of* Artificial Tangents, *A* Line *of* Sines, *A* Meridian Line *according to Mr.* Wright's *Projection; and the* Scale *of* Equal Parts, *by which the* Numbers *were taken off for the Graduating these* Scales; *and a* Line *of* Longitude, *with a* Scale *of* Reduction.

I. TO divide the *Line* of *Numbers*, you must prepare a *Ruler* of what length you please, and also a *Scale* of *Equal Parts*, divided into 100 or 1000. But if you divide the *Artificial Tangents* and *Sines* with the *Line* of *Numbers*, it is best to divide the *Line* into 2000 Parts. This *Table* is taken out of the *Logarithms*, by rejecting the *Index* or first *Figure*, and as many of the last *Figures* as you see convenient, according to the length of your *Line*. Then suppose you were to make the first 2 or 20, take with your *Compass* 301 equal Parts, and lay it from 1 to 2, and the same distance will reach from 10 in the middle to 20. In the like manner do with the rest; for 3 or 30 equal Parts is 477, and for 4 or 40, the *Log.* Parts is 602: as you may easily perceive, by what is written.

A Table *for the Division of the* Line *of* Artificial Numbers.

Num.	*Log. Parts.*	*Num.*	*Log. Parts.*	*Num.*	*Log. Parts.*	*Num.*	*Log. Parts.*	*Num.*	*Log. Parts.*
1	00	21	322	41	612	61	785	81	908
2	30	22	342	42	623	62	792	82	914
3	48	23	362	43	633	63	799	83	919
4	60	24	380	44	643	64	806	84	924
5	70	25	398	45	653	65	813	85	929
6	78	26	415	46	663	66	819	86	934
7	84	27	431	47	672	67	826	87	939
8	90	28	447	48	681	68	832	88	944
9	95	29	462	49	690	69	839	89	949
10	100	30	477	50	700	70	845	90	954
11	41	31	491	51	707	71	851	91	959
12	79	32	505	52	716	72	857	92	964
13	114	33	518	53	724	73	863	93	968
14	146	34	531	54	732	74	869	94	973
15	176	35	544	55	740	75	875	95	978
16	204	36	556	56	748	76	880	96	982
17	230	37	568	57	756	77	886	97	987
18	255	38	580	58	763	78	892	98	991
19	279	39	591	59	771	79	898	99	996
20	301	40	602	60	778	80	903	100	1000

II. *How to divide the* Line *of* Artificial Tangents *on the* Ruler.

THe *Artificial Tangents* are made in the ſame manner as other *Lines* before directed; beginning at 1 on the *Line* of *Numbers*. So 106, taken off the former *Scale*, and applied upward, will make 40 *Minutes* on your *Scale*: So for 1 and 89 *Degrees* the *Part* anſwering thereunto is 242, with them do in like manner, and ſo of the reſt, until you have finiſhed the whole *Line* or *Scale*, as you may ſee in the *Figure*.

III. *A* Table *for the Diviſion of the* Line *of* Artificial Tangents *into* Degrees *and* Minutes.

Min.	Deg. Tang. 0	Deg. Tang. 1	Deg. Tang. 2	Deg. Tang. 3	Deg. Tang. 4	Deg. Tang. 5	Deg. Tang. 6	Deg. Tang. 7	Deg. Tang. 8	Deg. Tang. 9	Deg. Tang. 10	Deg. Tang. 11	Min.
0	00	242	543	719	845	942	1022	1089	1148	1200	1246	1289	60
10	46	308	578	743	862	956	1034	1099	1157	1208	1254	1295	50
20	76	367	610	765	879	970	1045	1110	1166	1216	1261	1303	40
30	94	418	640	786	896	983	1057	1119	1174	1224	1268	1308	30
40	66	464	668	807	912	997	1068	1129	1183	1231	1275	1315	20
50	166	505	694	826	927	1009	1078	1138	1191	1239	1282	1321	10
Min.	89	88	87	86	85	84	83	82	81	80	79	78	Min.
	12	13	14	15	16	17	18	19	20	21	22	23	
0	1327	1363	1396	1428	1457	1485	1512	1537	1561	1546	1606	1628	60
10	1334	1369	1402	1433	1462	1490	1516	1541	1565	1588	1610	1631	50
20	1340	1375	1407	1438	1467	1494	1520	1545	1569	1592	1614	1635	40
30	1346	1380	1413	1443	1472	1499	1524	1549	1573	1595	1617	1638	30
40	1352	1386	1418	1448	1476	1503	1529	1553	1576	1599	1621	1642	20
50	1358	1391	1423	1453	1480	1507	1533	1557	1580	1603	1624	1645	10
Min.	77	76	75	74	73	72	71	70	69	68	67	66	Min.
	24	25	26	27	28	29	30	31	32	33	34	35	
0	1648	1669	1688	1707	1726	1744	1761	1779	1796	1812	1829	1845	60
10	1652	1672	1691	1710	1729	1747							50
20	1655	1675	1694	1713	1732	1750	1767	1784	1801	1818	1834	1850	40
30	1659	1678	1698	1716	1735	1753							30
40	1662	1682	1701	1719	1738	1755	1873	1790	1807	1823	1840	1856	20
50	1665	1685	1704	1723	1741	1758							10
Min.	65	64	63	62	61	60	59	58	57	56	55	54	Min.
	36	37	38	39	40	41	42	43	44	45			
0	1861	1877	1893	1908	1924	1939	1954	1970	1985	2000			60
20	1866	1882	1898	1913	1929	1944	1959	1975	1990				40
40	1872	1887	1903	1919	1934	1949	1964	1980	1995				20
Min.	53	52	51	50	49	48	47	46	45				Min.

IV. *How to divide the* Scale *or* Line *of* Artificial Sines *into* Degrees *and* Minutes.

HOw to make this *Line*, was ſhewn by making the laſt. And if your *Line* of *Equal Parts* be divided into 100, or as they be reckoned 1000, you may omit the laſt *Figure* of the *Number*: But if you number the *Scale* to 2000, as the *Tables* are made, then if you would ſet off the *Sine* of 30 *Degrees*, the *Parts* anſwering thereunto are 1699; therefore take off your *Scale* of *Equal Parts* with your *Compaſſes* 1699, and it will reach from the beginning to 30 *Degrees* on the *Line* of *Sines*.

So I hope you underſtand how to do the reſt, it being made ſo plain and eaſie for the meaneſt capacity.

A Table

A Table *for the Division of the* Artificial Sines *on the* Ruler.

Minutes.	Deg. Sine. 0	Deg. Sine. 1	Deg. Sine. 2	Deg. Sine. 3	Deg. Sine. 4	Deg. Sine. 5	Deg. Sine 6	Deg. Sine 7	Deg. Sine. 8	Deg. Sine. 9	Deg. Sine. 10
0	00	242	543	719	843	940	1019	1086	1143	1194	1240
10	46	309	577	742	861	954	1031	1096	1152	1202	1247
20	76	367	610	764	878	968	1043	1106	1161	1210	1254
30	94	418	640	786	895	981	1054	1116	1170	1218	1261
40	06	464	668	806	910	994	1065	1125	1178	1225	1267
50	163	505	694	825	926	1007	1075	1134	1186	1232	1274
Min.	11	12	13	14	15	16	17	18	19	20	21
0	1280	1318	1352	1384	1413	1440	1466	1490	1513	1534	1554
10	1287	1323	1357	1389	1418	1445	1470	1494	1516	1537	1558
20	1293	1329	1363	1394	1422	1449	1474	1498	1520	1540	1561
30	1300	1335	1368	1398	1427	1453	1478	1501	1523	1544	1564
40	1306	1341	1373	1403	1431	1457	1482	1505	1527	1548	1567
50	1312	1346	1378	1408	1436	1462	1486	1509	1530	1551	1570
Min.	22	23	24	25	26	27	28	29	30	31	32
0	1573	1592	1609	1626	1642	1657	1672	1685	1699	1712	1724
10	1577	1595	1612	1629	1644	1659	1674	1688			
20	1580	1598	1614	1631	1647	1662	1676	1690	1703	1716	1728
30	1583	1601	1618	1634	1649	1664	1679	1692			
40	1586	1603	1620	1637	1652	1667	1681	1694	1708	1720	1732
50	1589	1606	1623	1639	1654	1669	1683	1697			
Min.	33	34	35	36	37	38	39	40	41	42	43
0	1736	1747	1758	1769	1779	1789	1799	1808	1817	1825	1834
20	1740	1751	1762	1773	1783	1792	1802				
40	1744	1755	1766	1776	1786	1796	1805				
Min.	44	45	46	47	48	49	50	51	52	53	54
0	1842	1849	1857	1864	1871	1878	1884	1890	1896	1902	1908
Min.	55	56	57	58	59	60	61	62	63	64	65
0	1913	1918	1923	1928	1933	1937	1942	1946	1950	1954	1957
Min.	66	67	68	69	70	71	72	73	74	75	76
0	1961	1964	1967	1970	1973	1976	1978	1980	1983	1985	1987
Min.	77	78	79	80	81	82	83	84	85		90
0	1988	1990	1992	1993	1995	1996	1997	1998	1998		000

V. *How to make a* Meridian Line *according to the true* Sea-Chard, *or Mr.* Wright's *Projection.*

THis *Line* is made out of the *Table* of *Meridian parts*, in *Book* 4. *Chap.* 7. which is to every 10 *Minutes* of *Latitude*, nearer we have no *Chards* or *Plots* made, which I have as yet ſeen; but they may be made by Mr. *Wright's Tables* to every *Minute*, if any perſon will be ſo curious.

For the Graduating this *Line* in the *Scale*, you muſt note the *Number* anſwering to the firſt *Degree* is 200; therefore divide the *Degrees* of the *Equinoctial* into 20 Equal Parts, which ſtand for 200 of the *Numbers* of your *Table*. As for *Example*,

Suppoſe you would make the firſt 10 *Degrees* from the *Æquator*, towards either of the *Poles*, on the *Scale*; the *Number* anſwering 10 *Degrees* is 201, (omitting the laſt figure 0) you may take out of the *Line* of *Longitude* (whichare the Equal Parts of the ſame *Line* by which you made all the reſt) 201 Parts, and lay that diſtance from the beginning for 10 *Degrees*; and for 20 *Degrees* 408; and for 30 *Degrees* 629; and ſo of the reſt.

But if you are to make a particular *Line*, you muſt take the difference of the *Degrees* and *Minutes*, as ſhall be fully ſhewn in the *Treatiſe* of making a general and particular *Sea-Chard*, according to Mr. *Wright's* Projection.

There is demonſtrated and ſhewn the making of *Mercator's Scale*, to meaſure the Diſtance in any *Parallel* of *Latitude* in the true *Sea-Chart*.

VI. *How to divide the* Scale *of* Reduction.

THis *Scale* is part of a *Line* of *Numbers*, twice as large as the *Line* of *Numbers* on the *Mathematical Scale*, beginning at 10 and proceeding to 40; and may be made by the former *Table* for the diviſion of the *Line* of *Numbers*.

Provide a *Scale* in which the Equal Parts are twice as large, as thoſe by which you divided the former *Line* of *Numbers*, and then the *Numbers* in the *Table*; beginning at 10 and ending at 40, ſhall give the diſtances to divide the *Scale* of *Reduction*.

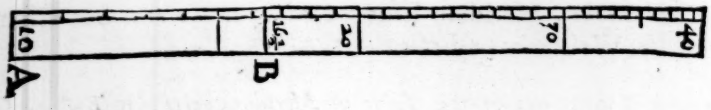
As for inſtance, againſt 11 ſtands 41, therefore 41 ſuch Parts whereof your *Scale* contains 1000, ſhall ſhall reach from 10 to 11, and 79 from 10 to 12, 114 from 10 to 13; and ſo of the reſt.

The Uſe of this *Scale* ſhall be ſhewn in the Fifth *Book*, *Of Surveying Land*.

A Table for the Diviſion of the Scale of Reduction.

	Statute Acres.
10	272 25
11	255 00
12	189 06
13	161 10
14	138 91
15	121 00
16	106 35
16½	100 00
17	094 21
18	84 03
19	75 42
20	68 07
21	61 73
22	56 25
23	51 47
24	47 27
25	43 56
26	40 27
27	37 35
28	34 73
29	32 37
30	30 25
31	28 33
32	26 59
33	25 00
34	23 55
35	22 21
36	21 01
37	19 89
38	18 85
39	17 90
40	17 02

CHAP.



CHAP. V.

A Table *for the Diviſion of the* Artificial Rhomb, *or* Points, Halves, *and* Quarters *on the* Travis-Scale.

THe Uſe of this *Table* is eaſily underſtood: The firſt *Column* is the *Points* in one quarter of the *Compaſs*, and the ſecond their Names in the whole; The third the *Degrees* anſwering to each quarter of a *Point* in the *Quadrant*; The fourth the *Sines* and *Equal Parts* anſwering thereunto; The fifth the *Points* for the *Tangents*; The ſixth the *Tangent* anſwering to each *Quarter-Point*.

Points.	*Nor. South.*	*Deg.*	*Min.*	*Sine rhom.*		*Tang. rhom.*
	N. b. E.	2	48	688		689
	S. b. E.	5	37	990		992
	S. b. W.	8	26	1166		1177
1	N. b. W.	11	15	1290	1. 7	1298
	N. N. E.	14	3	1385		1398
	S. S. E.	16	52	1462		1481
	S. S. W.	19	41	1527		1553
2	N. N. W.	22	30	1582	2. 6	1617
	N. E. b. N.	25	18	1630		1673
	S. E. b. S.	28	7	1673		1727
	S. W. b. S.	30	56	1710		1777
3	N. W. b. N.	33	45	1744	3. 5	1824
	N. E.	36	33	1774		1870
	S. E.	39	22	1802		1914
	N. W.	42	11	1827		1957
4	S. W.	45	00	1849	4	2000
	N. E. b. E.	47	48	1869		
	S. E. b. E.	50	37	1890		
	S. W. b. W.	53	26	1904		
5	N. W. b. W.	56	15	1919		
	E. N. E.	59	3	1933		
	E. S. E.	61	52	1945		
	W. S. W.	64	41	1956		
6	W. N. W.	67	30	1965		
	E. b. N.	70	18	1973		
	E. b. S.	73	7	1989		
	W. b. S.	75	56	1986		
7	W. b. N.	78	45	1991		
		81	33	1995		
	Eaſt & *Weſt.*	84	22	1997		
		87	11	1999		
		90	00	2000		

The

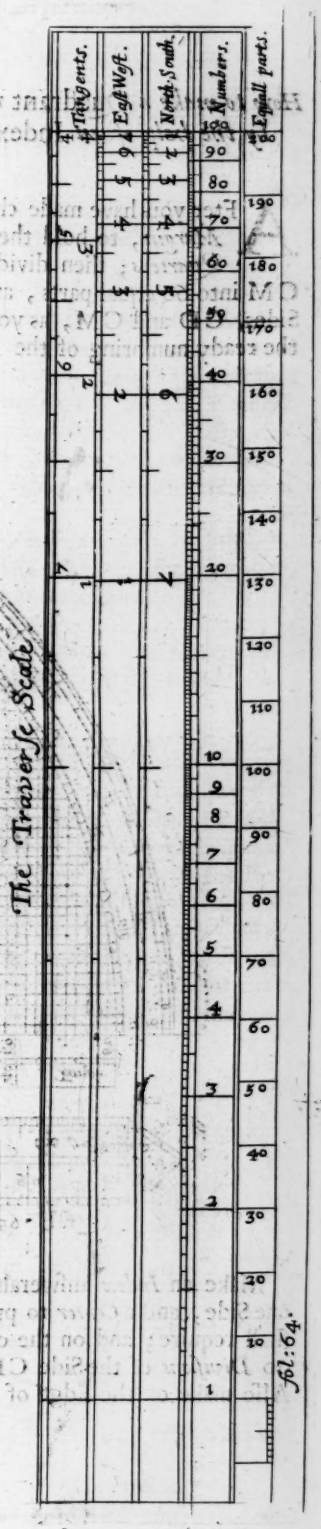
The Deſcription of the Travis-Scale.

This *Scale* is made by the foregoing *Table*; only the *Line* of *Sines* is there but once, and here the *Parts* anſwering each *Quarter* are twice put down, or in two *Lines* marked with *N. S.* which ſtand for *Northing* and *Southing*, and *E. W.* ſignifies *Eaſting* and *Weſting*. The firſt is the *Sine*, the ſecond is the *Sine Complement* of the *Angle* that any *Point* or *Quarter* maketh with the *Meridian*.

One Example *I will give the Learner.*

Suppoſe you were to ſet the firſt and ſeventh *Rhomb* or *Artificial Point* on the *Sines*, which is 11 *Degrees* 15 *Minutes*, the *Equal Parts* anſwering thereunto is 1290; therefore take 129 of your *Scale* of *Equal Parts*, and lay it from the beginning upwards, and you have by that diſtance the firſt and ſeventh *Rhomb* of your *Scale*.

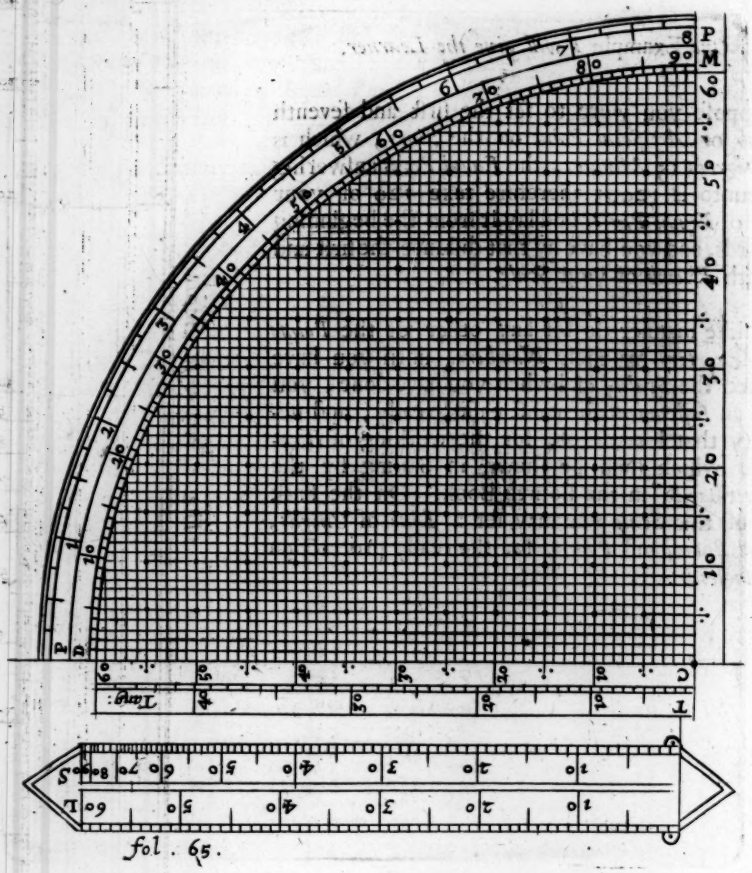
In like manner do for any other of the *Points* and *Quarters* by theſe *Numbers*, until you have finiſhed the *Scale*; and when you have done, you have an *Inſtrument* the moſt eaſie, ready, and neceſſary that I know of, for the working of *Traviſes*, which ſhall be ſhewn in Sailing by the *Plain Chard*, in the Fourth Book. On the back ſide of this *Scale* you may ſet a *Line* of *Chords*, *Equal Parts*, and *Points*, for the ready protraction of *Angles*.



CHAP. VI.

How to make a Quadrant *which will reſolve many Queſtions in* Aſtronomy, *by the help of an* Index; *and alſo very uſeful in* Navigation.

After you have made choice of the *Radius* of your *Quadrant* CD, draw the *Margin*, to hold the *Degrees* of the *Quadrant* and the *Figures*, *Points*, and *Quarters*; then divide the *Semidiameter* or Side of the *Quadrant* CD and CM into 60 equal parts, and draw *Lines* to each of the Diviſions, parallel to the Sides, CD and CM, as you ſee in the *Figure*; and at every 5 make a *Point*, for the ready numbring of the *Diviſions*.



fol. 65.

Make an *Index* anſwerable to the *Radius* CD, with a *Line* of *Sines* on the one Side, and a *Center* to put over the *Center-Pin* of the *Quadrant* C, as occaſion ſhall require; and on the other Edge make a *Line* of *Equal Parts*, equal to the 60 *Diviſions* of the Side CD, with a *Center* in like manner to remove at pleaſure. Alſo make on the Edge of the *Quadrant* a *Tangent-Line*.

The

The Uſe of the *Quadrant* in *Aſtronomy.*

SECT. I.

Having the Latitude *of the Place and the* Sun's Declination, *To find the Time of the* Sun-riſing *and* Setting.

EXAMPLE.

The *Latitude* 51 *Deg.* 30 *Min. Northward*, and the *Declination* 20 *Degrees Northerly*, the difference of *Aſcenſion* will be found thus:

Firſt, Lay the *Center* at E of the *Index*, over the *Braſs-Pin* in the *Center* of the *Quadrant* at C, and lay the Edge of the *Index* E L to the *Latitude* of the Place on the *Arch* D M; and from the *Tangent-Line* on the Edge of the *Quadrant* take 20 *Degrees* the *Sun*'s *Declination*; and lay that diſtance from the *Center* at C towards D, at that diſtance run with your Eye along the *Parallel-Lines*, and mark where it interſects the Edge of the *Index*, and likewiſe obſerve where the *Index* cuts thoſe *Lines* that are parallel to C D; there follow that *Parallel-Line* to the *Arch*, and the *Degrees* from D to that *Parallel-Line* will be 27 *Deg.* $\frac{1}{4}$, the difference of *Aſcenſion.*

The *Degrees* reſolved into *Hours* and *Minutes*, is 1 *Hour* 49 *Min.* which ſubtracted from 6, is 4 of the Clock and 11 *Min.* for the *Sun Riſing* in the Morning, and added to 6, gives 7 of the Clock 49 *Min.* his *Setting* in the Evening.

SECT. II.

Having the diſtance of the Sun *from the next* Æquinoctial Point, *To find his* Declination.

EXAMPLE.

The *Sun* being either in 29 *Degrees* of *Taurus*, or 1 *Deg.* of *Aquarius*, or 1 *Deg.* of *Leo*, or 29 *Deg.* of *Scorpio*, that is 59 *Degrees* from the next *Æquinoctial Point*, To find his *Declination*, do thus; Put the *Center* of the *Line* of *Sines* on the *Pin*, and lay the Edge of the *Index* to 23 *Deg.* $\frac{1}{2}$ the *Sun*'s greateſt *Declination*, reckoned from M towards D; then count the *Sun*'s diſtance 59 *Deg.* on the *Line* of *Sines* on the *Index*, and putting one Foot of your *Compaſſes* to that *Degree*, with the other take the neareſt diſtance to the *Side* C M, and apply that diſtance in the *Line* of *Sines* on the *Index*, from the *Center*, and the other Foot will reach to 20 *Degrees*, the *Declination* required.

SECT. III.

Having the Latitude *of the* Place, *and the* Declination *of the* Sun, *To find the* Sun's *true* Amplitude *from the* Eaſt *and* Weſt.

EXAMPLE.

Suppoſe the *Latitude* be 13 *Degrees Northerly*, and the *Sun*'s *Declination* 20 *Degrees Northward*, the *Sun*'s *Amplitude* is required.

Put the *Center* of the *Side* of the *Index* on which is the *Line* of *Sines* on the *Center* of the *Quadrant*, and lay the Edge to 13 *Deg.* which is the *Latitude*, then count from M 20 *Degrees* of *Declination*, and carry your Eye along the *Parallel-Lines* from that *Degree* of the *Arch*, and mark what *Degree* it cuts of the *Index* on the *Line* of *Sines*, as in this *Queſtion* it doth 20 *Deg.* $\frac{1}{2}$ *Northerly*, and that is the *Amplitude* required.

Secondly; Suppoſe you were about the *Cape* of *Virginia*, in *Latitude* 37 *Deg.* $\frac{1}{2}$, and *Declination* 10 *Deg. Southerly*, if you work as before-directed, you will find the *Amplitude* to be 12 *Deg.* $\frac{3}{4}$ *Southerly.*

Note. The *Amplitude* is the diſtance of the *Riſing* or *Setting* of the *Sun* or *Stars* from the true *Eaſt* and *Weſt Points* of the *Horizon.*

As for the foregoing *Example*; In the *Latitude* of 13 *Deg.* the *Sun* or any *Star* having *North-Declination* 20 *Deg.* they will riſe 20 *Deg.* $\frac{1}{2}$ to the *Northward* of the *Eaſt*, and ſet 20 *Deg.* $\frac{1}{2}$ to the *Northward* of the *Weſt.* But if the *Declination* had been 20 *Deg. South*, then they would have riſen 20 *Deg.* $\frac{1}{2}$ to the *Southward* of the *Eaſt*, and ſet 20 *Deg.* $\frac{1}{2}$ to the *Southward* of the *Weſt.*

And ſo if you bring theſe *Degrees* into *Points* and *Quarters*, and uſe the *Variation-Compaſs* upon the *Inſtrument* for the *Tides*, in the Firſt Book, Pag. 6. you may readily rectifie the *Compaſs* you Steer by.

SECT. IV.

The Uſe of the Quadrant *and* Variation-Compaſs, *on the* Inſtrument *for ſhifting of* Tydes.

The *Variation-Compaſs* contains two Parts or *Rundles*, being the two uppermoſt in the aforeſaid *Inſtrument*, moving one upon the other, as there you ſee. The biggeſt of the two uppermoſt *Rundles* may repreſent the *Compaſs* you Steer the Ship by, which is ſubject to Variation; and the upper *Compaſs* repreſents the true *Compaſs* that never varieth, whereby you have a neceſſary *Inſtrument* to rectifie the *Compaſs* by the help of this *Quadrant.*

Admit I am in the *Latitude* of 27 *Deg. Northerly*, and *Declination* 20 *Deg. Northward*, and I obſerve the *Sun*'s *Riſing* to be *Eaſt* and by *North*, by the *Compaſs*; the *Variation* in that *Latitude* is required.

The *Sun* having *North-Declination*, and in the *Latitude* of 27 *Deg. North*, the *Sun* will riſe from the *Eaſt Northerly*, which is 22 *Deg.* $\frac{1}{2}$ *E. N. E.* But by the *Compaſs*, the *Sun* did riſe at *E. b. N.* Therefore it plainly appears that there is a *Point* Variation.

Therefore on the *Inſtrument* aforeſaid you muſt always bring the true *Point* of *Riſing* and *Setting* on the upper *Rundle*, to the *Point* of *Riſing* or *Setting*, by the *Compaſs*, on the middle *Rundle*; and being ſet in this Poſition, you will find the *E. b. N.* of the *Compaſs* to be the true *E. N. E.* and the *W. b. N.* to be the true *W.* and the *N. b. E.* to be the true *N.* and the *S. b. W.* to be the true *S.* and *S. E.* $\frac{1}{2}$ *Point Southerly*, to be the true *S. E. b. E.* $\frac{1}{2}$ *Southerly*; and the *South* $\frac{1}{4}$ *Eaſt*, to be the *S. b. E.* $\frac{1}{4}$ *Eaſt.* And ſo you may do in all other *Obſervations.*

SECT. V.

Several Problems *of* Navigation *wrought by the* Quadrant.

PROBL. I.

To find the Number of Miles *or* Minutes *of the* Equinoctial *anſwering to one* Degree *of* Longitude, *in any* Degree *of* Latitude.

In Sailing by the *Compaſs*, the Courſe ſometimes is upon a great *Circle*, ſometime upon a *Parallel* to the *Æquator*, but moſt commonly upon a *Spiral Line*, winding towards one of the *Poles*, but never paſſing through them.

If the Courſe hold upon a great *Circle*, it is either *North* or *South* under ſome *Meridian*; or *Eaſt* or *Weſt* under the *Æquator.*

But

But if the Courſe be *Eaſt* or *Weſt*, in any of the *Parallels* to the *Æquator*, then

As Radius *is to* 60 Miles, *or* 20 Leagues, *the Meaſure of one* Degree *of the* Æquator:
So is the Sine-Complement *of the* Latitude, *to the* Miles *or* Leagues *in one* Degree *of* Longitude *in that of* Latitude.

Deg.	*Min.*	*Miles.*
00	00	60
18	12	57
25	15	54
31	48	51
36	52	48
41	25	45
45	34	42
49	28	39
53	08	36
56	38	33
60	00	30
63	01	27
66	25	24
69	30	21
72	32	18
75	31	15
78	28	12
81	23	09
84	15	06
87	08	03

But if you would know by the foregoing *Quadrant* the *Miles* anſwering to a *Degree* of *Longitude* in each *Parallel* of *Latitude*, it is thus:

Set the *Ear* E on the *Center-Pin*, and reckon the *Degrees* of *Latitude* from D: to which ſet the Edge of the *Index*, and note the *Parallel-Line* that meets with the *Degree* of *Latitude*; carry your Eye on that *Parallel* till it meet with the Side CD, and there it ſhews you the Number of *Miles* anſwering to a *Degree* in that *Latitude*.

EXAMPLE.

In the *Latitude* of 18 *Degrees* 12 *Min.* ſet the *Index* to 18 *Degr.* $\frac{1}{4}$ from D, and the *Parallel-Line* meeting that *Degree*, follow with your Eye (or a Pin) to the Edge, and you will find it to be 57 *Miles*; ſo in the *Latitude* of 31 *Deg.* 48 *Min.* you will find 51 *Miles*; as in the *Table* annexed.

PROBL. II.

To find how many Leagues *do alter one* Degree *of* Latitude, *on every* Point *and* Quarter-Point *of the* Compaſs.

As the Sine-Complement *of the* Rhomb *from the* Meridian, *is to* 20 Leagues:

So is the Radius, *to the* Leagues *anſwering to one* Degree *upon the* Rhomb.

By which Proportion was made this *Table* annexed.

Rhombs.	*Number of Leagues.*	
	Leag.	*part.*
$\frac{1}{4}$	20	02
$\frac{1}{2}$	20	10
$\frac{3}{4}$	22	22
1	28	39
$1\frac{1}{4}$	20	62
$1\frac{1}{2}$	20	90
$1\frac{3}{4}$	21	24
2	21	65
$2\frac{1}{4}$	22	12
$2\frac{1}{2}$	22	68
$2\frac{3}{4}$	23	32
3	24	05
$3\frac{1}{4}$	24	90
$3\frac{1}{2}$	25	87
$3\frac{3}{4}$	26	99
4	28	08

Rhombs.	*Number of Leagues.*	
	Leag.	*part.*
$4\frac{1}{4}$	29	78
$4\frac{1}{2}$	31	52
$4\frac{3}{4}$	33	57
5	36	00
$5\frac{1}{4}$	38	90
$5\frac{1}{2}$	42	43
$5\frac{3}{4}$	36	76
6	52	26
$6\frac{1}{4}$	59	37
$6\frac{1}{2}$	68	90
$6\frac{3}{4}$	82	31
7	102	52
$7\frac{1}{4}$	136	30
$7\frac{1}{2}$	205	14
$7\frac{3}{4}$	400	60
8	*Infinit.*	

Suppoſe by the *Quadrant* it were required to anſwer this *Queſtion:*

Sailing N. N. E. *from* 40 Degrees *of* North-Latitude, *How many* Leagues *ſhall the* Ship *run before ſhe can come to* 41 Deg. *becauſe this is the ſecond* Rhomb *from the* Meridian.

Therefore ſet the Side of the *Index* EL to the ſecond *Point* from the *Meridian*, and reckon from C 20 *Leagues* towards D, and with your Eye (or a Pin) follow the *Parallel-Line* to the *Index*, and you will find it cut $21\frac{1}{2}$ *Leagues*, the number of *Leagues* you muſt Sail before you can raiſe 1 *Degree* of *Latitude*.

PROBL.

PROBL. III.

By the Rhomb, *and* Diſtance, *To find the difference of* Latitude.

The diſtance upon the *Rhomb* 21 *Leagues* ½ the *Rhomb N. N. E.* therefore ſet the *Index* to the ſecond *Point*, and count 21 *Leagues* ½ thereon, and run your Eye up the *Parallel-Line* you there meet with, and reckon the *Leagues* from the *Center* C to that *Line*, and you will find it 20 *Leagues*, which is the difference of *Latitude* required.

PROBL. IV.

By the Rhomb, *and both* Latitudes, *To find the Diſtance in the* Rhomb.

As ſuppoſe the one Place given were in the *Latitude* 40 *Deg.* the ſecond Place in the *Latitude* 41 *Deg.* and the Courſe 2 *Points* from the *Meridian*.

Set the *Index* to the *Rhomb*, and account 20 *Leagues*, which is the difference of *Latitude*, from C towards D, and carry your Eye on that *Parallel* to the *Index*; and there it will cut the diſtance upon the *Rhomb*, which in this *Queſtion* is 21½ *Leagues*.

PROBL. V.

By the Diſtance and both Latitudes, *To find the* Rhomb.

Suppoſe one Place to be in the *Latitude* of 40 *Deg.* and the ſecond 20 *Leagues* further *Northward*, and the diſtance was 21½ *Leagues*; to find the Courſe.

From the *Center* C reckon 20 *Leagues* towards D, follow that *Parallel*, and ſet the diſtance on the *Index* to that *Parallel*, and look in the *Arch* of the *Quadrant*, and you will find the *Rhomb* 2 *Points* from the *North*.

PROBL. VI.

By the difference of Meridians, *and* Latitude *of both Places, To find the* Rhomb.

Suppoſe one Place to be in the *Latitude* of 40 *Deg.* and the other in 41 *Deg.* and the departure 8 *Leagues* ½.

Firſt, Count from C towards D the difference of *Latitude* 20 *Leagues*, on that *Parallel* count 8 *Leagues* ½, to that *Point* put the *Index*; and in the *Arch* you will find the Courſe to be 2 *Points* from the *Meridian*.

PROBL. VII.

By the Rhomb *and both* Latitudes, *To find the departure from the* Meridian.

Let the *Rhomb* be 2 *Points* from the *Meridian*, the one *Latitude* given 40 *Deg.* the other *Latitude* 41 *Deg.*

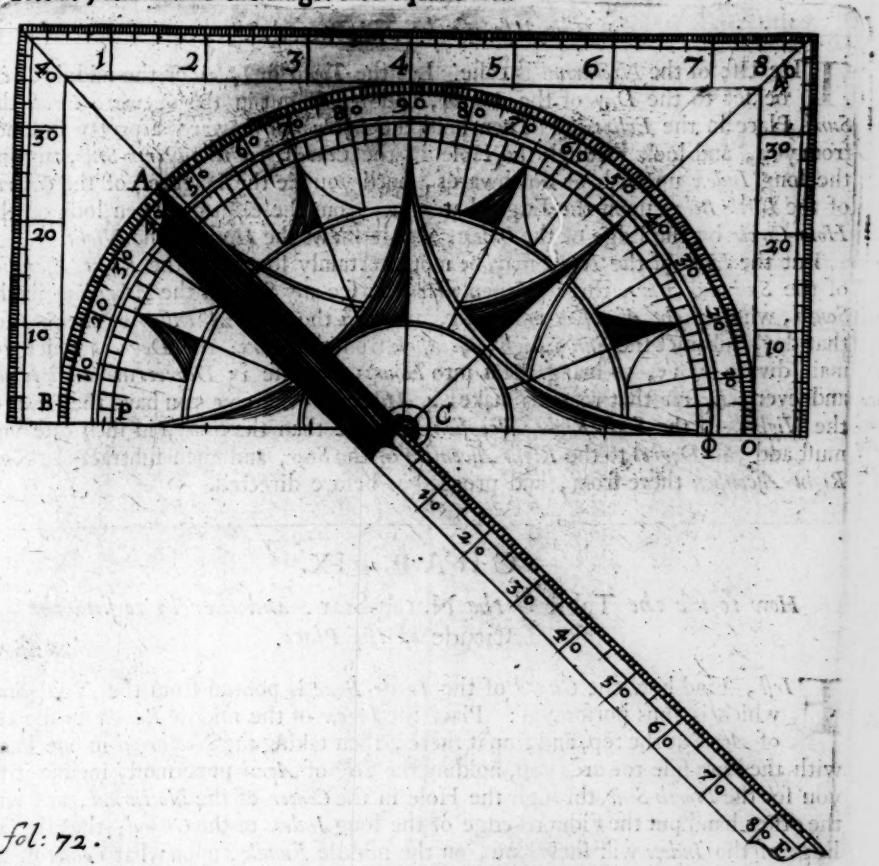
Set the *Index* to the ſecond *Point* from the *Meridian*, and count 20 *Leagues* the difference of *Latitude* from C towards D, upon that *Parallel* reckon the departure to the *Index*, which you will find in this *Queſtion* 8 *Leagues*

CHAP. VII.

How to make an Uſeful Protractor.

THis *Inſtrument* is beſt to be made in *Braſs*. On the *Center* C draw the *Semicircle* BO, and divide it into twice 90, or 180 *Degrees*, as you ſee in the *Figure*; and let the ſixteen *Points* of the *Compaſs* with the *Quarter-Points* be ſet in the inward *Circle* P Φ, and let the *Index* AE be two *Diameters* and ½ long, and divided from the *Center* to the end of the *Index* into 100 equal Parts, which are accounted ſometimes *Leagues*, and ſometimes *Perches*; or any other denomination, according as you have occaſion to uſe it.

Let the *Index* be faſtned to the *Center* with a *Braſs Rivet*, and through the midſt of the *Rivet* there muſt be a *Hole* drill'd; through which you muſt put a *Pin* or *Needle*, and divide the Edges into equal Parts.



fol: 72.

And now you have a neceſſary *Inſtrument*, which will protract any *Travis* or Draught of *Land* upon *Paper*, with as much ſpeed as any *Inſtrument* I ever yet knew, the Uſe whereof ſhall be ſhewn in this *Treatiſe*.

CHAP. VIII.

The Projection *of the* Nocturnal.

IT conſiſts, as you ſee, of three Parts. The greateſt or Handle-part hath on it two *Circles* divided: On the firſt or outmoſt is the *Ecliptick*, divided into 12 equal Parts, in which is put the 12 *Signs*; and each of thoſe 12 Parts is divided into 30 equal Parts, or *Degrees*, in each *Sign* numbered with 10, 20, 30, as you ſee in the *Figure*. The inward *Circle* is the 12 *Months* of the *Year*, and the *Days* in each *Month* equally divided, and numbred with 10, 20, 30.

The middle *Rundle* is equally divided into twice 12 *Hours*; and without that is a *Circle* divided into 32 *Points* of the *Mariner's Compaſs*, with the *Quarter-Points*. The upper part is an *Index*, of a convenient length; all three being faſtned with a piece of *Braſs*, ſo that the *Center* is an Hole through which you are to ſee the *North-Star*. You may make it of good dry *Box*.

The Uſe of the Nocturnal.

THe Uſe of the *Nocturnal* is eaſie. Let the *Tooth* or *Index* of the middle *Circle* be ſet to the *Day* of the *Month*, and it will cut in the outward *Circle* the *Sun*'s Place in the *Ecliptick*. Then hold the *Inſtrument* upward a pretty diſtance from you, and look through the Hole in the *Center*, to the *North-Star*, turning the long *Index* upwards or downwards, until you ſee the brighteſt of the *Guards* of the *Little Bear*, upon the Edge that comes from the *Center*. Then look on the *Hour-Circle* by the Edge of the *Index*, and it ſhews the *Hour* of the *Night*.

But the *Hour* of the *Night* may be more certainly found by the *Right Aſcenſion* of the *Sun* and *Stars*, thus; When that you ſee any *Star* on the *Meridian* in the *South*, whoſe *Right Aſcenſion* is known, and alſo the *Right Aſcenſion* of the *Sun* for that day, ſubtract the *Sun*'s *Right Aſcenſion* from the *Stars*; the *Degrees* which remain divide by 15, to bring them into *Hours*; becauſe 15 *Degrees* make an *Hour*, and every *Degree* that remains makes 4 *Minutes*; whereby you have the *Hour* of the *Night*. If the *Sun*'s *Right Aſcenſion* be more than the *Stars*, in ſuch caſe you muſt add 360 *Degres* to the *Right Aſcenſion* of the *Star*, and then ſubtract the *Sun*'s *Right Aſcenſion* there-from, and proceed as before directed.

How to place the Nocturnal *for the* Pole-Star.

CHAP. IX.

How to uſe the Table *of the* North-Star, *and thereby to find the* Latitude *of the Place.*

FIrſt, Find how the *Guard* of the *Little Bear* is poſited from the *North-Star*, which is thus performed: Place the *Index* of the middle *Rundle* to the 26th of *April* at the top, and ſtop it there; then taking the *Nocturnal* in one hand, with the Fore-ſide towards you, holding the 26th of *April* uppermoſt, incline it till you ſee the *North-Star* through the Hole in the *Center* of the *Nocturnal*, and with the other hand put the Fiducial-edge of the long *Index* to the *Guard*; then the ſaid Edge of the *Index* will ſhew you, on the middle *Rundle*, upon what *Points* of the *Compaſs* the *Guard* bears from the *North-Star*: Then obſerve the height of the *Pole-Star* exactly as you can; and knowing by your *Dead Reckoning* what *Latitude* you are in, look for the neareſt to that *Latitude* in the top of the *Table*; and againſt the *Point* of the *Compaſs* which the *Guard-Star* is upon, in the firſt *Column* of the *Table*, and under the *Column* of your *Latitude*, you ſhall find the number of *Degrees* and *Minutes* the *Pole-Star* is either above or below the *Pole*, according to the direction of the laſt *Column* of the *Table*; which you muſt thus make uſe of: If the *Star* be above the *Pole*, ſubtract the *Number* in the *Table* from the height of the *Star* obſerved; but if the *Star* be under the *Pole*, then add the *Number* found in the *Table* to the height obſerved, by which you ſhall have the height of the *Pole*.

For

For Example. Suppose the *Latitude* to be near 39 *Degrees*, and observing the *Pole-Star*, suppose you find the *Altitude* 40 *Degrees*, and the *Guard-Star* bears *N. N. E.* from the *Pole*; therefore look for *N. N. E.* in the first *Column*, and right under 40 *Degrees* of *Latitude* in the same *Line* with *N. N. E.* you will find the *Declination* to be 1 *Deg.* 30 *Min.* subtract that from 40 *Deg.* the *Altitude* observed leaves the true *Latitude* 38 *Deg.* 30 *Min.* But if the *Guard-Star* had been *S. S. W.* then the *Pole-Star* had been 1 *Deg.* 33 *Min.* under the *Pole*; which being added to the *Altitude* observed 40 *Deg.* the *Latitude* would have been exactly 41 *Deg.* 33 *Min.* So the *Star*'s *Altitude* by observation being 55 *Deg.* the *Guard* bearing *S. E. b. S.* the *Declination* against that *Point* is 2 *Deg.* 30 *Min.* which added to 55, makes 57 *Deg.* 30 *Min.* for the *Latitude*: But if your estimate *Latitude* had been near 50, and the *Guard* bears from the *Pole N. W. b. N.* the *Declination* against that *Point* is 2 *Deg.* 30 *Min.* subtracted from 55 *Degrees*, the *Altitude* observed, there remains 52 *Deg.* 30 *Min.* the *Latitude* of the Place.

A Table *of the* North-Star's Altitude *in these several* Latitudes.

	The Point of the Compass.	0		20		30		40		50		60		70		
		D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	
If the former of the Guards *be ascending from the* North *or lower part of the* Meridian.	North.	2	10	2	10	2	10	2	09	2	09	2	08	2	07	*Above the* Pole.
	N. b. E.	1	53	1	53	1	53	1	52	1	52	1	51	1	49	
	N. N. E.	1	31	1	31	1	30	1	30	1	29	1	28	1	25	
	N. E. b. N.	1	06	1	05	1	04	1	03	1	02	0	01	0	58	
	N. E.	0	39	0	38	0	37	0	36	0	35	0	33	0	30	
	N. E. b. E.	0	10	0	09	0	08	0	07	0	06	0	04	0	01	
	E. N. E	0	18	0	19	0	20	0	21	0	22	0	23	0	26	*Under the* Pole.
	E. b. N.	0	49	0	50	0	50	0	51	0	52	0	53	0	56	
	East	1	15	1	15	1	16	1	17	1	18	1	19	1	21	
	E. b. S.	1	38	1	39	1	39	1	40	1	41	1	42	1	44	
	E. S. E.	2	00	2	00	2	00	2	00	2	00	2	01	2	02	
	S. E. b. E.	2	15	2	15	2	15	2	15	2	16	2	16	2	16	
	S. E.	2	25	2	25	2	25	2	25	2	25	2	25	2	25	
	S. E. b. S.	2	30	2	30	2	30	2	30	2	30	2	30	2	30	
	S. S. E.	2	29	2	29	2	29	2	29	2	29	2	29	2	29	
	S. b. E.	2	22	2	22	2	22	2	22	2	22	2	22	2	22	
If the former of the Guards *be descending from the* South *or upper part of the* Meridian.	South.	2	10	2	10	2	10	2	11	2	11	2	11	2	12	*Under the* Pole.
	S. b. W.	1	58	1	53	1	54	1	53	1	55	1	55	1	57	
	S. S. W.	1	31	1	32	1	32	1	33	1	34	1	35	1	38	
	S. W. b. S.	1	07	1	07	1	08	1	10	1	11	1	13	1	13	
	S. W.	0	39	0	40	0	41	0	40	0	43	0	44	0	47	
	S. W. b. W.	0	10	0	11	0	12	0	13	0	14	0	16	0	19	
	W. S. W.	0	19	0	19	0	17	0	16	0	15	0	13	0	10	*Above the* Pole.
	W. b. S.	0	48	0	47	0	46	0	45	0	44	0	43	0	42	
	West.	1	15	1	14	1	13	1	12	1	11	1	10	1	08	
	W. b. N.	1	39	1	39	1	38	1	37	1	36	1	35	1	33	
	W. N. W.	2	00	1	59	1	59	1	58	1	58	1	57	1	56	
	N. W. b. W.	2	15	2	15	2	14	2	14	2	14	2	13	2	12	
	N. W.	2	25	2	25	2	25	2	25	2	24	2	24	2	24	
	N. W. b. N.	2	30	2	30	2	30	2	30	2	30	2	30	2	30	
	N. N. W.	2	29	2	29	2	29	2	29	2	29	2	29	2	29	
	N. b. W.	2	22	2	22	2	22	2	22	2	22	2	21	2	21	

CHAP. X.

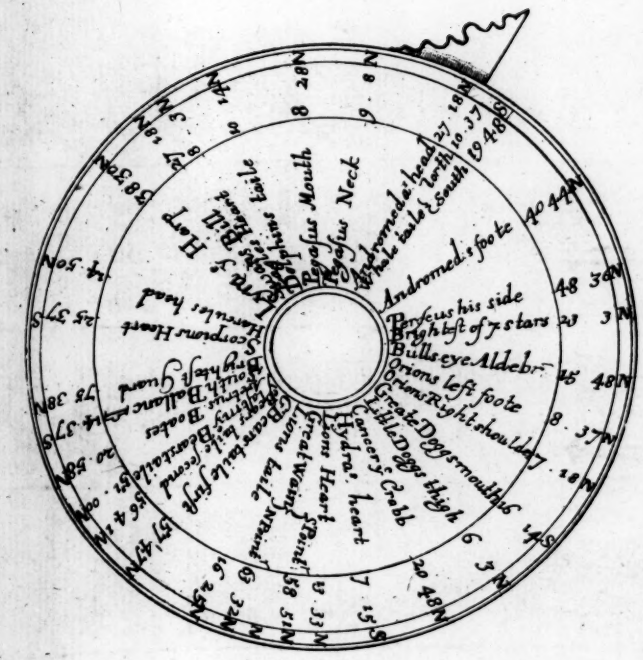
How to make an Uſeful Inſtrument *of the* Stars, *and by it to know when any of thoſe* Stars *will come to the* Meridian, *at any time of the* Year.

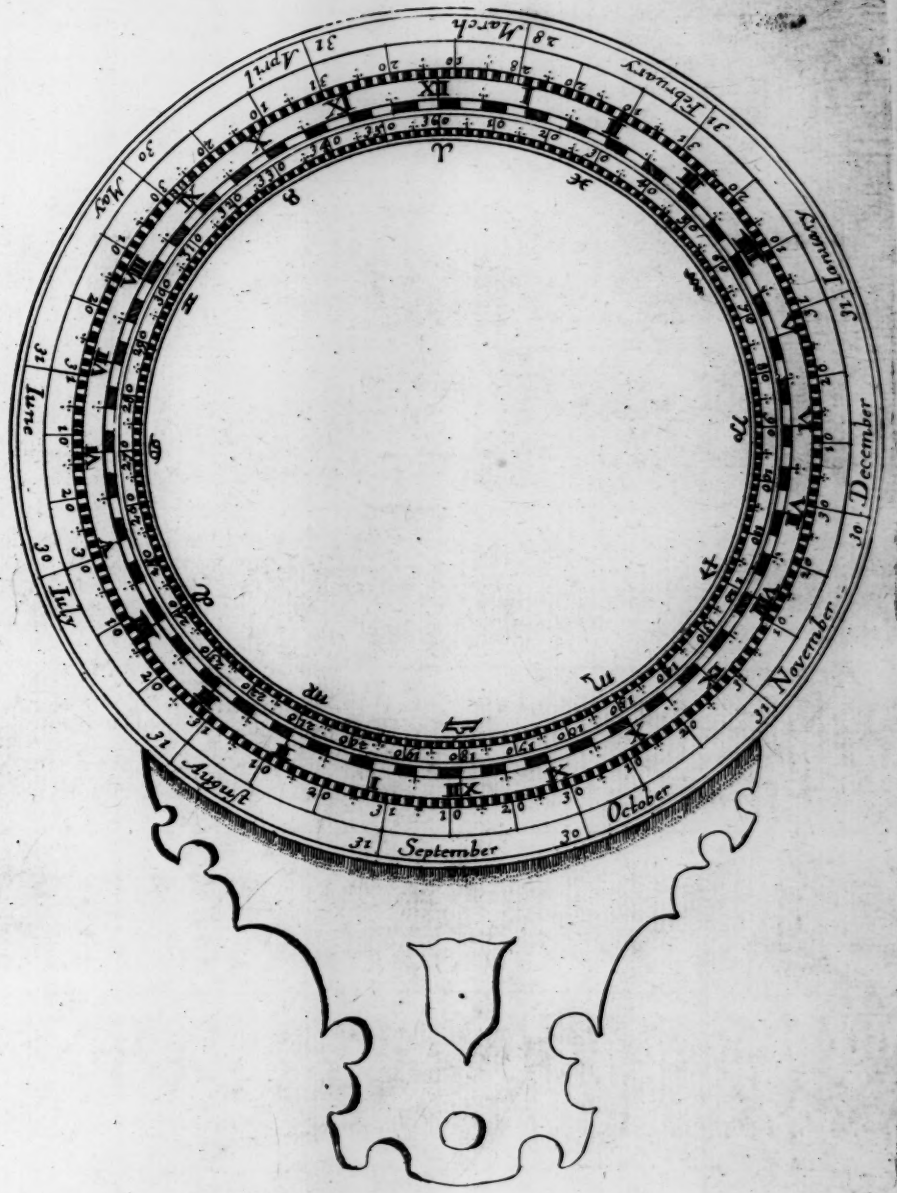
THis *Inſtrument* conſiſteth of two parts, which are two *Rundles*; it may be made on the back-ſide of the foregoing *Nocturnal*: On the greater *Rundle* are three *Circles* divided; the outermoſt is the 12 *Months* of the *Year*, beginning the 10th of *March*, the day the *Sun* enters into *Aries*; and the *Days* equally divided according to the Number of *Days* in each *Month*. The ſecond *Circle* is equally divided into 24 *Hours*. And the third and inward *Circle* repreſents the *Equinoctial*, divided into 360 *Degrees*; by it is accounted the *Right Aſcenſion* of theſe 31 *Stars* in the *Table* following.

A Table *of the* Longitude, Latitude, Right Aſcenſions, *and* Declinations, *of* 31 *of the moſt Notable* Fixed Stars; *Calculated from* Tycho *his* Tables, *rectified for the Year of our Lord* 1671.

	Longitude.	*Latitude.*	*Right Aſcen.*	*Declination.*	*Nor. Sout.*	
In the Whale's *Tail, the Brighteſt.*	27 56 ♈	20 47 S	06 45	19 48	S	2
The Bright Star *in the* South *Foot of* Andromeda.	09 39 ♉	27 46 N	25 57	40 44	N	2
The Bright Star *in the Right Side of* Perſeus.	27 17 ♉	30 05 N	44 16	48 36	N	2
The Brighteſt of the Seven Stars *or* Pleiades.	25 24 ♉	04 00 N	52 00	23 03	N	3
The South *Eye of the* Bull, Aldebaran.	05 12 ♊	05 31 S	64 17	15 48	N	1
The Bright Star *in the left Foot of* Orion, Rigel.	12 17 ♊	31 11 S	74 44	08 37	S	1
Orion's *right Shoulder.*	24 12 ♊	16 06 S	84 23	07 18	N	1
The glittering Star *in the Mouth of the great* Dog.	09 35 ♋	39 30 S	97 42	16 14	S	1
The little Dog's *Thigh*, Procyon.	21 18 ♋	15 57 S	110 34	06 03	N	2
In the South *Arm of the* Crab.	09 03 ♌	05 08 S	130 07	13 48	N	3
The Bright Star *called the Heart of the* Hydra.	22 45 ♌	22 24 N	137 54	07 15	S	1
The Lion's *Heart*, Regulus.	25 17 ♌	00 26 N	147 43	13 33	N	1
The lower of the Pointers.	14 43 ♌	45 03 N	160 18	58 08	N	2
The Northern Pointer.	10 34 ♌	49 40 N	160 48	63 32	N	2
The Lion's *Tail.*	17 03 ♍	12 18 N	173 04	15 25	N	1
The firſt in the Tail of the great Bear.	04 10 ♍	54 18 N	189 53	57 47	N	2
The ſecond in the Tail.	10 56 ♍	56 22 N	197 37	56 41	N	2
The laſt in the Tail.	22 12 ♍	54 25 N	203 57	51 00	N	2
In the Skirt of Boötes *his Garment*, Arcturus.	19 39 ♎	31 02 N	210 13	20 58	N	1
The South Balance *of* Libra.	10 31 ♏	00 26 N	218 13	14 37	S	2
The Brighteſt of the Guards.	08 16 ♌	72 51 N	222 45	75 36	N	2
The Scorpion's *Heart*, Antares.	05 13 ♐	04 27 S	242 23	25 37	S	1
Hercules *his Head.*	11 31 ♐	37 23 N	254 12	14 50	N	3
The Bright Star *of* Lyra.	10 43 ♑	61 47 N	276 27	38 30	N	1
The Swan's *Bill.*	26 44 ♑	49 02 N	289 23	27 18	N	3
The Eagle's *Heart.*	27 09 ♑	29 21 N	293 41	08 03	N	2
The Dolphin's *Tail.*	09 32 ♒	29 08 N	304 24	10 14	N	3
The Mouth of Pegaſus.	27 22 ♒	22 07 N	322 03	08 24	N	3
The Bright Star *of* Pegaſus *Neck.*	11 39 ♓	17 41 N	336 21	09 08	N	3
The firſt Star *in the Wing of* Pegaſus, Marchab.	18 56 ♓	19 26 N	342 07	13 28	N	2
Andromeda's *Head.*	09 47 ♈	25 42 N	357 54	27 18	N	2

On


Andromeds head
Whale Taile
Perseus Neck
Andromeds foote
Perseus his side
Brightest of 7 stars
Bulls eye Aldebr
Orions left foote
Orions Right shoulder
Great Dogs mouth
Great Dogs thigh
Lesser Dog
Lesser Dogs Heart
Hydra, heart
Crab
Lions Heart
Lions tayle
Lions Mouth
Lions Back
Lions Breast
Lions Wast
Lions foote
Scorpions Heart
Hercules head
Hercules Hart
Bootes
Bootes his Girdle
Bootes his Staffe
Bootes his Knee
Bootes his Arme
Bootes his Head
Bootes his Shoulder
Bootes his Foote
Bootes his Hand
Bootes his Gowne
Bootes his Staffe
Bootes his Knee
Bootes his Arme
Bootes his Head
Bootes his Shoulder
Bootes his Foote
Bootes his Hand
Bootes his Gowne


January
February
March
April
May
June
July
August
September
October
November
December

folio 66 . . .

On the other *Rundle* or upper part, is placed the aforeſaid *Stars*; and any other you may ſet thereon, if you follow this *Rule*.

For *Example*, Firſt ſet the *Index* to the 10th day of *March*, and ſtop it faſt there, that it may not move, until you have placed the *Stars* on it which you intend. As ſuppoſe you would ſet the *Whale*'s *Tail* on the *Rundle*; look in the foregoing *Table*, and you will find his *Right Aſcenſion* 6 *deg.* 45 *min.* account 6 *deg.* $\frac{3}{4}$ on the *Equinoctial Circle*, and lay a *Ruler* from the *Center* over the 6 *deg.* 45 *min.* and draw the *Line* from the *Center* to the outward Edge of the upper *Rundle*, and thereon ſet the *Name* of the *Star*, next to that the *Declination* of the *Star*, and the *Letter S* or *N*, repreſenting *South* or *North Declination*.

Take this *Example* more. Suppoſe you would ſet on the *Lion*'s *Heart*: In the *Tables* I find his *Right Aſcenſion* is 147 *deg.* 43 *min.* reckon that *Number* on the *Equinoctial Circle*, and draw the *Line* as before-directed.

How to know the Hour *of the* Night *when any* Star *comes to the* Meridian.

SEt the *Index* of the upper *Rundle* to the *Day* of the *Month*, and right againſt the *Star* is the *Hour* of the *Night*, when the *Star* will be on the *Meridian*.

For *Example*, Suppoſe you would know the *Hour* of the *Night* the *Bull*'s *Eye* comes to the *Meridian* the 20th day of *October*: Set the *Index* to the *Day*, and right againſt the *Bull*'s *Eye* is $\frac{1}{4}$ of an *Hour* paſt 1, the time in the *Morning* that *Star* will be on the *Meridian South*. And in the ſame manner you may ſee the other *Stars*, at what *Hours* they come to the *Meridian* that *Day* and *Night*. For note the upper 12, is 12 at *Noon*, and the lower 12 is 12 at *Night*.

How to know the Hour *of the* Night, *by the* Stars *being on the* Meridian.

SUppoſe it were required to know the *Hour* of the *Night* the 10th of *December*, the brighteſt of the 7 *Stars* being on the *Meridian* in the *South*: Set the *Index* to the *Day* of the *Month*, and right againſt the brighteſt of the 7 *Stars*, is half an *Hour* paſt 9 at *Night*, which is the *Hour* required.

CHAP. XI.

of the Croſiers.

WHen the *Mariners* paſs the *Equinoctial Line* towards the *South*, ſo that they cannot ſee the *North-Star*, they make uſe of another *Star*, which is in the *Conſtellation* called the *Centaur*; which *Star*, with three other notable *Stars* in the ſame *Conſtellation*, make the *Figure* of a *Croſs*, for which cauſe they call them the *Croſiers*. And it is held for certain, That when that *Star* A (which of all four is neareſt the *South-Pole*) is perpendicular to the *Star* B, then it is rightly ſituated for Obſervation. And becauſe this *Star* A, which is called the *Cocks-foot*, is 28 *Degrees* from the *South-Pole*, it cometh to paſs, it being ſituated as before-ſaid, if we take the *Meridian Altitude* thereof, this

will ſhew how far we are diſtant from the *Equinoctial*. For if the ſaid Height be $28\frac{1}{2}$ *Degrees*, then are we under the *Equinoctial*: But if it be more than $28\frac{1}{2}$ *Deg.* then are we by ſo much paſt the *Equinoctial* toward the *South*: And if it be leſs than $28\frac{1}{2}$ *Deg.* ſo much as it wanteth, are we to the *North* of the *Equinoctial*.



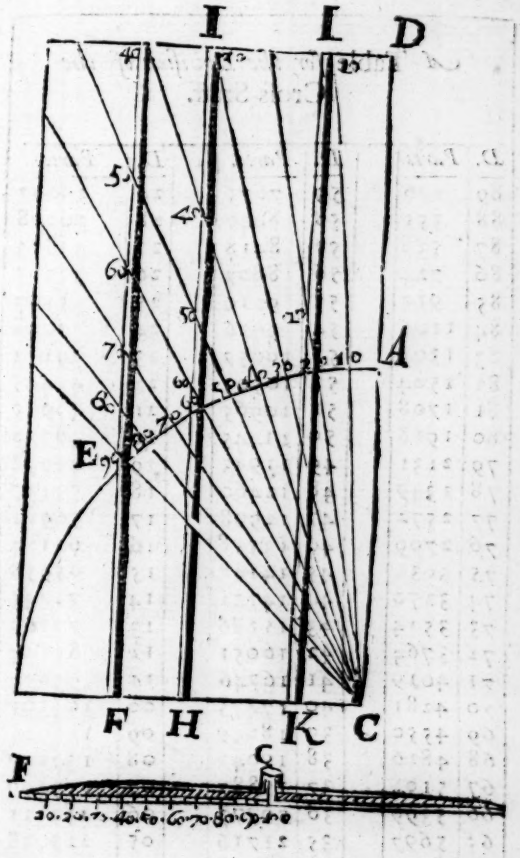
CHAP. XII.

How to make the Croſs-Staff.

THe *Mariner's Croſs-Staff* is that which by the *Aſtronomers* is called *Radius Aſtronomicus*, by which we obſerve the *Altitude* of the *Celeſtial Lights* above the *Horizon*. *Mathematicians* have invented many kinds of *Inſtruments*, whereof the *Croſs-Staff* and *Quadrant* are the moſt uſeful at *Sea*. It is not every Man's Work to make a *Croſs-Staff* or other *Inſtruments*, for want of Practice needful thereunto; yet notwithſtanding it is fit and neceſſary that a *Maſter*, his *Mates*, and *Pilot*, who have the Uſe thereof, ſhould at leaſt know when it is well made.

For to divide a *Croſs-Staff*, you may prepare a flat *Board* of good dry *Wood*, fifteen or ſixteen *Inches* broad, and about four *Foot* long: Paſte it well with good *Paper*; draw along the one Side a *Right Line*, as in the next following *Figure* CAD; from the *Point* C draw a *Perpendicular Line* upon AC, as CB, and upon the *Center* C draw the *Arch* AEB, being a *Quadrant* or fourth part of a *Circle*; divide that into two parts; the one half thereof, as AE, divide into 90 Equal Parts; firſt into three Parts, and each of the ſame again into three; theſe Parts into two, and each of the laſt into five: ſo the *Arch* AE ſhall then be divided into 90 Parts. Then take a ſtraight *Ruler*, lay the one end on the *Point* or *Center* C, the other upon each *Point* of the foreſaid ſeveral *Diviſions*, and draw ſmall *Lines* out of C, through each of the foreſaid *Points* or *Degrees* of the *Quadrant*, as long as the *Board* will permit, as you may ſee in the *Figure*. Then take a pair of *Compaſſes*, the half length of the *Croſs* that you would make for the *Staff*; prick it from the *Point* C towards B; as for example, from C to F, and from D to G; joyn theſe two *Points* with a *Line*, as GF; and even into ſuch Parts as that *Line* is cut, by the aforeſaid *Lines* coming out of the *Center* C, ſo muſt your *Staff* be divided, whether the *Croſs* be longer or ſhorter, as appeareth by the *Lines* HI and KL, which are drawn for *Croſſes*, the half length thereof is CH, or CK. If the foreſaid *Quadrant* be not well divided, or the *Lines* not well drawn, the *Staves* being divided there-from will alſo be faulty. Therefore they may be divided more exactly in manner as followeth.

Prepare



Prepare you a *Staff*, draw thereon a *Right Line* as long as your *Staff*, and take with a ſharp pair of *Compaſſes* the half Length of your *Croſs* for which you deſire to divide your *Staff*; prick it as often along the aforeſaid *Line* as you can. Divide each of the Lengths of the half *Croſs* into 1000 *Equal Parts*. Then prick upon the *Staff*, you would divide, from the *Center-end*, juſt half the Length of the *Croſs*; and make there a ſmall thwart *Stroke*. Off from thence prick for each *Degree* ſo many of the ſame *Parts* as the *Croſs* is divided in his half Length, according to the *Table* here annexed for every *Degree*. For the 89 *Degrees* you ſhall mark off from 90 the aforeſaid thwart *Stroke* $17\frac{8}{10}$ for 86 *Degrees*, $72\frac{8}{10}$ for the 80 *Degree* $191\frac{8}{10}$ of thoſe *Parts*, and ſo of the reſt. If you cannot divide the half *Croſs*, by reaſon he is ſo little, into 1000, divide him into 100, and leave out the two laſt *Figures*, and that ſhall ſatisfie your deſire: For 60 *Degrees* take 73, and for 50 *Degrees* 114, and for 80 *Degrees* 19 *Parts*, and ſo of the reſt.

A Table

A Table *for the Diviſion of the* Croſs-Staff.

D.	Parts	D.	Parts.	D.	Parts.
89	176	59	7675	29	28667
88	355	58	8040	28	30108
87	538	57	8418	27	31653
86	724	56	8807	26	33315
85	913	55	9210	25	35107
84	1106	54	9626	24	37046
83	1303	53	10057	23	39152
82	1504	52	10503	22	41445
81	1708	51	10965	21	43955
80	1918	50	11445	20	46713
79	2131	49	11943	19	49758
78	2349	48	12460	18	53137
77	2572	47	12998	17	56912
76	2799	46	13558	16	61154
75	3032	45	14142	15	65958
74	3270	44	14751	14	71445
73	3514	43	15386	13	77769
72	3764	42	16051	12	85144
71	4019	41	16746	11	93854
70	4281	40	17475	00	104301
69	4550	39	18239	09	117062
68	4826	38	19042	08	133007
67	5108	37	19887	07	153499
66	5399	36	20777	06	180811
65	5697	35	21716	05	219038
64	6003	34	22708	04	276332
63	6318	33	23759	03	371885
62	6643	32	24874	02	561810
61	6970	31	26059	01	1135886
60	7320	30	27321	00	*Infinite.*

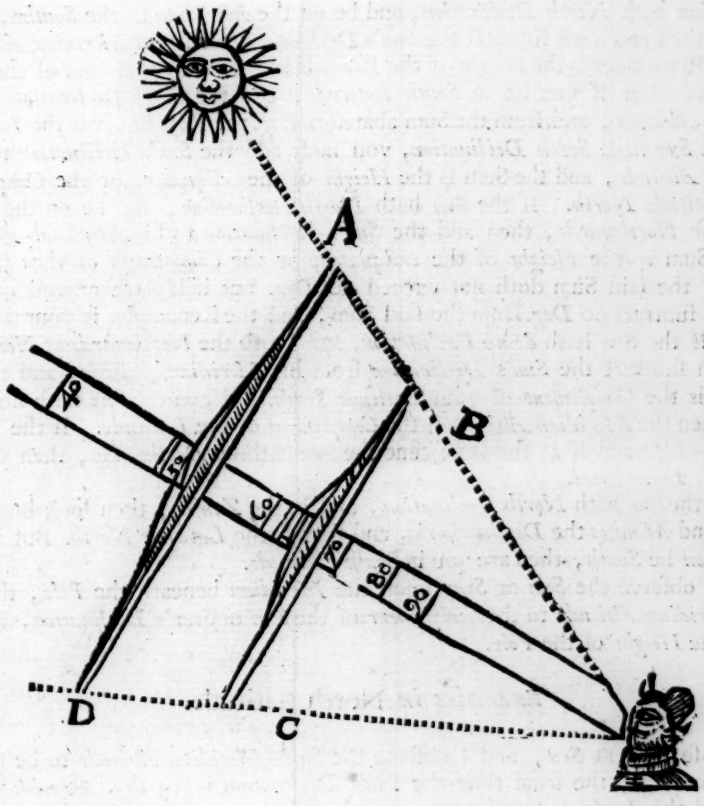
CHAP. XIII.

How to uſe the Croſs-Staff.

SEt the end of the *Croſs-Staff* to the outſide of the *Eye*, ſo that the end of the *Staff* come to ſtand right with the middle of the *Sights*. Then move the *Croſs* from you or towards you, holding it upright, and winking with your *Eye*, till that the upper end cut the *Center* of the *Sun* or *Star*, and the lower end cut the *Horizon*, the *Croſs* then ſhall ſhew upon the ſide of the *Staff* belonging thereunto, the *Degrees* of the *Altitude* of the *Sun* or *Star*. Note, The *Staff* is marked with two rows of *Numbers*, with 90 *Degrees* next the *Eye*, and diminiſhing from 90 to 80, 70, 60, *&c.* towards the outmoſt end: Alſo from the *Eye-end* they increaſe contrariwiſe towards the outmoſt end, as from 10 to 20, 30, *&c.* The firſt *Number* ſheweth you the *Altitude*, the ſecond *Number* the *Sun*'s *diſtance* from the *Zenith*.

The

The *Sun* or *Stars* being high above the *Horizon*, the *Croſs* is moved nearer the *Eye* than when they are but low and near the *Horizon*, and the *Eye* maketh a greater motion in looking up and down to the ends of the *Croſs*, than when the *Sun* or *Star* is low, and therefore ſubject to a greater Errour. The beſt means of all in my opinion is this; To try with two *Croſſes* ſet upon the like *Degrees*, how the *Staff* muſt be ſet, that they may ſee the ends of the two *Croſſes* in a *Right Line* one with the other.



Having found that, and then taking off one of the *Croſſes*, and ſetting the *Staff* again, in the ſame manner as before, all *Errours* will be prevented, which by the lifting up or down of the *Eye*, might any way happen.

EXAMPLE.

I deſire to obſerve the *Sun* or any *Star* in the *South*: I make my Eſtimation, as near as I can, how high it ſhall be, or take the *Height* of them a little before they ſhall come to the *South*, which I take to be 50 *Degrees*. I ſet therefore the two *Croſſes* each upon 50 *Degrees*, and the end of the *Staff* in the hollow of the *Eye-bone*, on the outſide of the *Eye*, and move the end of the *Staff* higher or lower till I ſee the end of both the *Croſſes* right one with the other, according as is ſhewn by theſe *Lines* AB and CD in the foregoing *Figure*; and keeping in memory that ſtanding of the *Staff*, I take off the one *Croſs*, and ſet the *Staff* again in the aforeſaid manner to the *Eye*, and obſerve the *Altitude* therewith, ſo avoiding the *Errour* mentioned.

In

In taking the *Height* of the *Sun* with the *Croſs-Staff*, they uſe red or blew *Glaſſes*, for the ſaving and preſerving the *Eyes*; yet it is notwithſtanding very troubleſom for the *Sight*, eſpecially if it be bright: Therefore the *Quadrant* is much better, as will be ſhewed in the next *Chapter*.

Thus I have ſhewed you how to take an Obſervation by the *Fore-ſtaff*. The next thing that followeth in courſe will be to ſhew you how to work your *Obſervation*; which to do, take notice of theſe following *Rules*.

To Work your Obſervation.

IF the *Sun* hath *North Declination*, and be on the *Meridian* to the *Southwards* of you, then you muſt ſubtract the *Sun*'s *Declination* from your *Meridian Altitude*, and that Remainder is the *Height* of the *Equinoctial*, or the *Complement* of the *Latitude North*. But if you be in *South Latitude*, add the *Sun*'s *Declination* to the *Meridian Altitude*, and from the Sum abate 90 *Deg.* the Remainder is the *Latitude*. But if the *Sun* hath *South Declination*, you muſt add the *Sun*'s *Declination* to your *Meridian Altitude*, and the Sum is the *Height* of the *Æquator*, or the *Complement* of the *Latitude North*. If the *Sun* hath *North Declination*, and be on the *Meridian* to the *Northwards*, then add the *Sun*'s *Declination* to his *Meridian Altitude*, and the Sum is the *Height* of the *Æquator*, or the *Complement* of the *Latitude South*, if the ſaid Sum doth not exceed 90 *Deg.* but if it doth exceed 90 *Deg.* you muſt ſubtract 90 *Deg.* from the ſaid Sum, and the Remainder is your *Latitude North*. If the *Sun* hath *South Declination*, and be to the *Northwards* at *Noon*, you muſt then ſubtract the *Sun*'s *Declination* from his *Meridian Altitude*, and the Remainder is the *Complement* of your *Latitude South*. When the *Sun* hath no *Declination*, then the *Meridian Altitude* is the *Complement* of the *Latitude*. If the *Sun* be in the *Zenith*, and if at the ſame time the *Sun* hath no *Declination*, then you are under the *Equinoctial*.

But if the *Sun* hath *North Declination*, and in the *Zenith*, then look how many *Degrees* and *Minutes* the *Declination* is, and that is the *Latitude North*. But if your *Declination* be *South*, then are you in *South Latitude*.

If you obſerve the *Sun* or *Star* upon the *Meridian* beneath the *Pole*, then add your *Meridian Altitude* to the *Complement* of the *Sun* or *Star*'s *Declination*, and the Sum is the *Height* of the *Pole*.

Examples in North Latitude.

SUppoſe I am at *Sea*, and I obſerve the *Sun*'s *Meridian Altitude* to be 39 *deg.* 32 *min.* and the ſame time the *Sun*'s *Declination* is 15 *deg.* 20 *min. North*; I demand the *Latitude* I am in.

	deg.	*min.*	
The Meridian Altitude	39	32	
The Declination North, *ſubtr.*	15	20	
The Complement *of the* Lat.	24	12	
	90	00	
The Latitude *I am in*	65	48	*North.*

Suppoſe I were in a *Ship* at *Sea* the 18th of *April*, *Anno* 1667. and by Obſervation I find the *Sun*'s *Meridian Altitude* to be 62 *deg.* 15 *min.* The *Latitude* is required.

	deg.	*min.*
The Meridian Altitude	62	15
The Declination North, *ſubtr.*	14	18
The Complement *of the* Latitude	47	57
	90	00
The Latitude *I am in*	42	03

Admit

In taking the *Height* of the *Sun* with the *Croſs-Staff*, they uſe red or blew *Glaſſes*, for the ſaving and preſerving the *Eyes*; yet it is notwithſtanding very troubleſom for the *Sight*, eſpecially if it be bright: Therefore the *Quadrant* is much better, as will be ſhewed in the next *Chapter*.

Thus I have ſhewed you how to take an Obſervation by the *Fore-ſtaff*. The next thing that followeth in courſe will be to ſhew you how to work your *Obſervation*; which to do, take notice of theſe following *Rules*.

To Work your Obſervation.

IF the *Sun* hath *North Declination*, and be on the *Meridian* to the *Southwards* of you, then you muſt ſubtract the *Sun*'s *Declination* from your *Meridian Altitude*, and that Remainder is the *Height* of the *Equinoctial*, or the *Complement* of the *Latitude North*. But if you be in *South Latitude*, add the *Sun*'s *Declination* to the *Meridian Altitude*, and from the Sum abate 90 *Deg.* the Remainder is the *Latitude*. But if the *Sun* hath *South Declination*, you muſt add the *Sun's Declination* to your *Meridian Altitude*, and the Sum is the *Height* of the *Æquator*, or the *Complement* of the *Latitude North*. If the *Sun* hath *North Declination*, and be on the *Meridian* to the *Northwards*, then add the *Sun*'s *Declination* to his *Meridian Altitude*, and the Sum is the *Height* of the *Æquator*, or the *Complement* of the *Latitude South*, if the ſaid Sum doth not exceed 90 *Deg.* but if it doth exceed 90 *Deg.* you muſt ſubtract 90 *Deg.* from the ſaid Sum, and the Remainder is your *Latitude North*. If the *Sun* hath *South Declination*, and be to the *Northwards* at *Noon*, you muſt then ſubtract the *Sun*'s *Declination* from his *Meridian Altitude*, and the Remainder is the *Complement* of your *Latitude South*. When the *Sun* hath no *Declination*, then the *Meridian Altitude* is the *Complement* of the *Latitude*. If the *Sun* be in the *Zenith*, and if at the ſame time the *Sun* hath no *Declination*, then you are under the *Equinoctial*.

But if the *Sun* hath *North Declination*, and in the *Zenith*, then look how many *Degrees* and *Minutes* the *Declination* is, and that is the *Latitude North*. But if your *Declination* be *South*, then are you in *South Latitude*.

If you obſerve the *Sun* or *Star* upon the *Meridian* beneath the *Pole*, then add your *Meridian Altitude* to the *Complement* of the *Sun* or *Star*'s *Declination*, and the Sum is the *Height* of the *Pole*.

Examples in North Latitude.

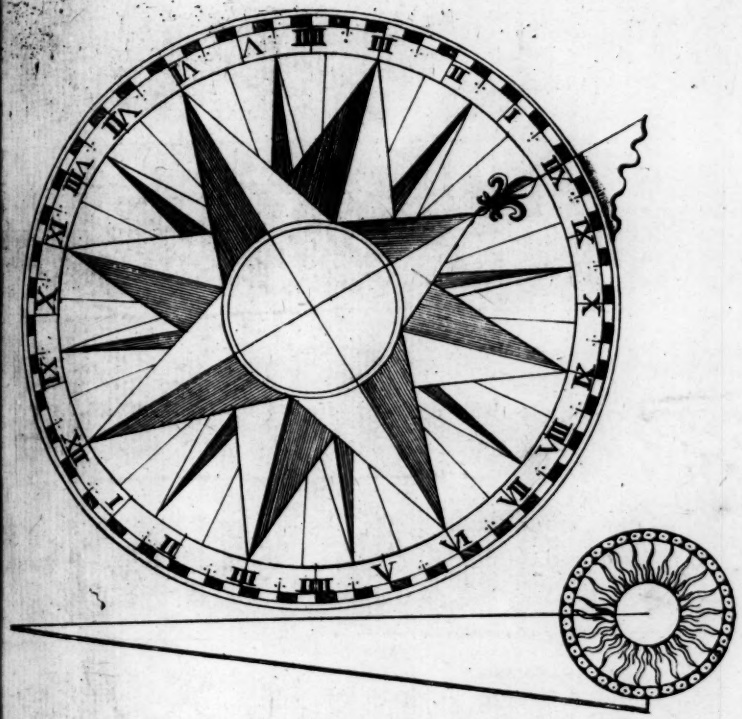
SUppoſe I am at *Sea*, and I obſerve the *Sun*'s *Meridian Altitude* to be 39 *deg.* 32 *min.* and the ſame time the *Sun*'s *Declination* is 15 *deg.* 20 *min. North*; I demand the *Latitude* I am in.

	deg.	*min.*	
The Meridian Altitude	39	32	
The Declination North, *ſubtr.*	15	20	
The Complement *of the* Lat.	24	12	
	90	00	
The Latitude *I am in*	65	48	*North.*

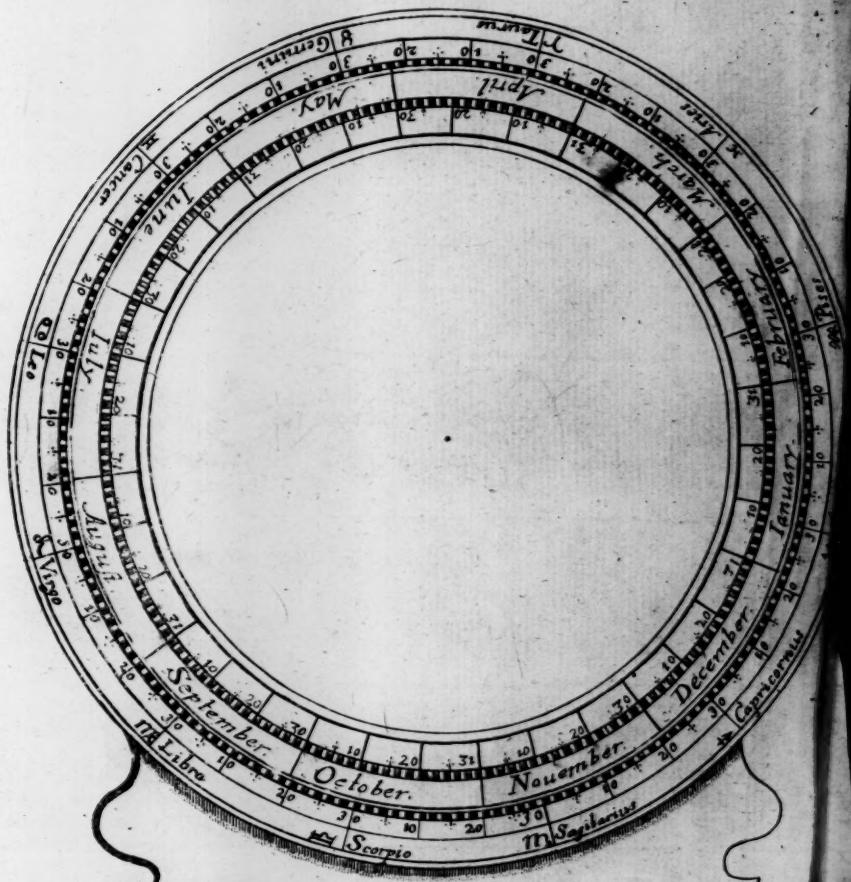
Suppoſe I were in a *Ship* at *Sea* the 18th of *April*, *Anno* 1667. and by Obſervation I find the *Sun*'s *Meridian Altitude* to be 62 *deg.* 15 *min.* The *Latitude* is required.

	deg.	*min.*
The Meridian Altitude	62	15
The Declination North, *ſubtr.*	14	18
The Complement *of the* Latitude	47	57
	90	00
The Latitude *I am in*	42	03

Admit



A Nocturnal.


Aprill
May
June
July
August
September.
October.
Nouember.
December.
January.
February.
March.
Aries
Taurus
Gemini
Cancer
Leo
Virgo
Libra
Scorpio
Sagitarius
Capricornus
Aquarius
Pisces

Admit you were in a *Ship* at *Sea* the 5th of *November*, *Anno* 1679. and I find the *Sun*'s *Meridian Altitude* to be 24 *deg.* 56. *min.* The *Latitude* is required.

	deg.	*min.*
The Meridian Altitude	24	56
The Declination South, *add*	18	37
The Complement *of the* Latitude	43	33
	90	00
The Latitude *I am in*	46	27

Suppose a *Ship* at *Sea* the 27th of *May*, *Anno* 1666. and I find the *Sun*'s *Meridian Altitude* by Observation 56 *deg.* 45 *min.* The *Latitude* is required.

	deg.	*min.*
The Meridian Altitude	56	45
The Declination North, *subtr.*	22	46
The Complement *of the* Latitude	33	59
	90	00
The Latitude *required I am in*	56	01

Admit a *Ship* at *Sea* the 11th of *June* 1668. and find the *Sun*'s *Meridian Altitude* by Observation 79 *deg.* 30 *min. North.* It is required to find the *Latitude* I am in.

	deg.	*min.*
The Meridian Altitude	79	30
The Declination North, *add*	23	31
	103	01
	90	00
The Latitude *I am in*	13	01

Suppose I were at *Sea* the 14th of *May* 1693. and the *Meridian Altitude* of the *Sun* was 69 *deg.* 3 *min. North*, I demand the *Latitude* the *Ship* is in at that time.

	deg.	*min.*	
The Meridian Altitude	69	03	
The Declination North, *add*	20	57	
	90	00	
	90	00	
The Ship *is under*	00	00	*the* Equinoctial.

Examples in South Latitude.

Suppose I were at *Sea* in a *Ship* the second of *June*, *Anno* 1666. and I find the *Sun*'s *Meridian Altitude* by Observation to be 64 *deg.* 45 *min.* The *Latitude* the *Ship* is in, is required.

	deg.	*min.*	
The Meridian Altitude North	64	45	
The Declination North, *add*	23	15	
The Complement *of the* Latitude	88	00	
	90	00	
The Latitude *the* Ship *is in*	02	00	*South.*

Suppose a *Ship* at *Sea* the 28th of *December*, *Anno* 1695. and in *Longitude* 169 *deg. East*, and I find the *Meridian Altitude* by Observation to be 59 *deg.* 52 *min.* The *Latitude* the *Ship* is in, is required. The *Declination* in the *Meridian* of *London* for the 28th of *December*, is 22 *deg.* 25 *min.* and the daily difference of *Declination* is at this time 8 *min.* Therefore if you look in the *Table of Proportion* following, you will find the *Proportional Minutes* to be about 4; which you must

add to the *Declination* of the *Meridian* of *London*, and the Sum will be the *Declination* for the *Longitude* 169 *deg. Eaſt*, which is 22 *deg.* 29 *min.*

	deg.	*min.*	
The Meridian Altitude North	59	52	
The Declination South, *ſubtr.*	22	29	
The Complement *of the* Latitude	37	23	
	90	00	
The Latitude *the* Ship *is in*	52	37	*South.*

Suppoſe I were at *Sea* in a *Ship* the 29th of *June*, 1679. and I find the *Sun's Meridian Altitude* to be 62 *deg.* 23 *min. North*, The *Latitude* is required.

	deg.	*min.*	
The Meridian Altitude North	62	23	
The Declination North, *add*	22	26	
The Complement *of the* Latitude	84	49	
	90	00	
The Latitude *the* Ship *is in*	05	11	*South.*

Admit a *Ship* were at *Sea*, the *Sun's Declination* 13 *deg.* 53 *min. South*, and the *Sun's Meridian Altitude* 80 *deg.* 43 *min. South*, The *Latitude* is required.

	deg.	*min.*	
The Declination South	13	53	
The Meridian Altitude	80	43	*add.*
	94	36	*the Sum.*
Subtr.	90	00	
The Latitude *the* Ship *is in*	04	36	*South.*

If you obſerve the upper part of the *Sun*, you muſt ſubtract 16 *min.* if you obſerve the lower part of the *Sun*, you muſt add 16 *min.* for the *Sun's Semidiameter*, and the *Sum* will be the true *Altitude* of the *Sun's Center*.

Examples of the Stars *in* North Latitude.

SUppoſe I am at *Sea*, and obſerve the Brighteſt of the 7 *Stars* upon the *Meridian*, and find his *Meridian Altitude* to be 47 *deg.* 20 *min.* and the *Latitude* were required.

	deg.	*min.*	
The Declination *of this* Star *is*	23	03	*North.*
The Meridian Altitude	47	20	
Subtract the North Declination	23	03	
The Complement *of the* Latitude	24	17	
	90	00	
The Latitude *I am in*	65	43	*North.*

Admit I were at *Sea*, and obſerve *Hydra's Heart* on the *Meridian*, his *Altitude* is 36 *deg.* 15 *min.* and his *Declination* is 7 *deg.* 15 *min. South*, The *Latitude* of the Place is demanded.

	deg.	*min.*	
The Meridian Altitude *is*	36	15	
The Declination *is* South	07	15	*add.*
The Height *of the* Equinoctial *above*	43	30	*the* Horizon.
	90	00	
The Latitude *the* Ship *is in*	46	30	*required.*

This you ſee is plain, and needs no further *Precept*, but what is already ſaid concerning the *Sun*.

CHAP.

CHAP. XIV.

A Deſcription of the Quadrant.

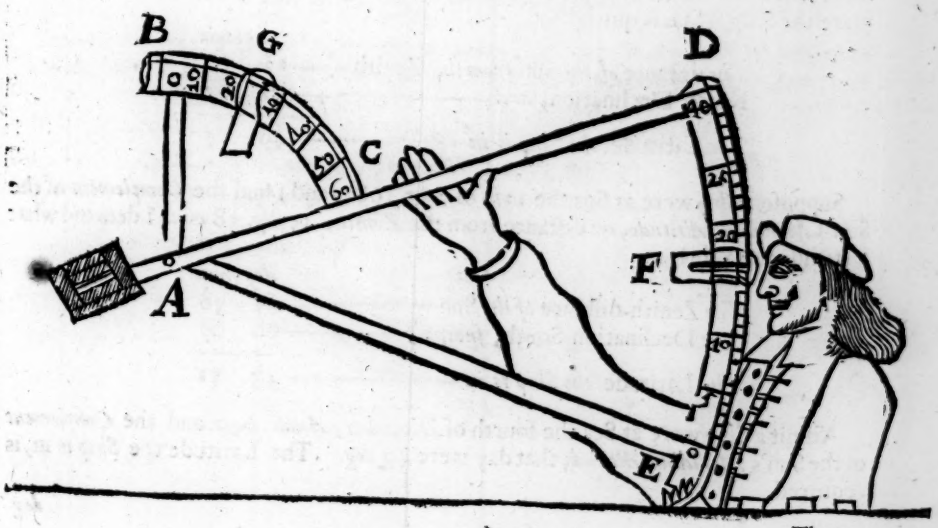
THe *Quadrant* is formed of two *Arches*, a leſſer and a greater; the leſſer *Arch* contains 60 *Degrees*, and is called the *Sixty Arch*; the greater contains 30 *Degrees*, and is called the *Thirty Arch*. To the *Quadrant* alſo belong three *Sights* or *Vanes*; the *Horizon-Vane* at A, the *Shadow-Vane* at G, and the *Sight-Vane* at F.

The Uſe of the Back-Staff *or* Quadrant.

SEt the *Vane* G to 15 or 20 *deg.* leſs than the *Complement* of the altitude of the *Sun* required; then look through the *Vane* F, to the upper Edge of the Slit in the *Horizon-Vane*, and cauſe the upper Edge of the Shadow of the *Shadow-Vane* to fall upon the upper Edge of the *Slit* in the *Horizon-Vane*, and then if you ſee all *Skie* and no *Water*, then put your *Sight-Vane* a little higher towards D; but if you ſee all *Water* and no *Skie*, then pull your *Eye-Vane* lower towards E; and when you have done ſo obſerve again; and then if you ſee the *Shade* lie upon the upper part of the *Slit*, on the *Horizon-Vane*, and you at the ſame time do ſee the *Horizon* through the *Horizon-Vane*, then that is all you can do until the *Sun* be riſen higher; and ſo tend the *Sun* until he be upon the *Meridian*; and when he is deſcending, or as we commonly ſay, fallen, you will ſee nothing but the *Skie*; and your *Vanes* being faſt in this poſture, you have done obſerving the *Sun* upon the *Meridian* that day:



The Figure of the Quadrant



Therefore reckon the *Degrees* from B to the upper ſide of the *Vane* G; to it add the number of *Degrees* from E to the *Eye-Sight*, and their *Sum* is the *Diſtance* of the *Sun* from the *Zenith*.

Rules to find the Latitude *by obſerving with the* Quadrant.

Firſt, If the *Sun* hath *North Declination*, and you be in *North Latitude*, and the *Sun* upon the *Meridian*, *South* of you; then if you add the *Sun's Declination* to his *Zenith-Diſtance*, (that is, the *Complement* of the *Sun's Meridian-Altitude*) the *Sum* will be the *Latitude* you are in.

But if the Sun hath *South Declination*, and you be in *North Latitude*, you muſt ſubtract the *Declination* from the *Complement* of the *Meridian Altitude*, and the Remainder will be the *Latitude* the Ship is in.

If you be to the *Southward* of the *Æquinoctial*, and the Sun's *Declination* Southerly, and come to the *Meridian* in the *North*; in ſuch caſe you muſt add the *Declination* to the *Zenith-diſtance*, and the Sum will be your *Latitude*.

But if the Sun be to the *Northwards* of the *Æquinoctial*, (that is, have *North-Declination*) and come to the *Meridian* in the *North*, you muſt ſubtract the *Declination* from the *Zenith-diſtance*, and the Remainder will be the Latitude.

If you be in *North* Latitude, and the Sun's *Declination North*; and the Sun come to the Meridian in the *North*; or if you be *South* Latitude, and the Sun having *South Declination* come to the Meridian in the *South*: in both theſe caſes ſubtract the *Zenith-diſtance* from the *Declination*, the Remainder is the Latitude of the place.

If you obſerve the Sun's *Meridian Altitude* under the *Pole*, adde the Sun's *Declination* to the *Zenith-diſtance*, and ſubtract the ſum from 180 *deg.* the Remainder is the Latitude of the place.

Examples in North Latitude.

ADmit being in a *Ship* at Sea the fifth of *May*, 1694. and by Obſervation I find the *Sun* to be diſtant from the *Zenith* 37 *deg.* 52 *min.* being upon the *Meridian* I require the Latitude the *Ship* is in.

	deg.	*min.*
The diſtance *of the* Sun *from the* Zenith	37	52
North Declination	19	02
The Latitude *required the* Ship *is in.*	56	54

Suppoſe a Ship at *Sea* the 29*th* of *July*, *Anno* 1682. and I find the *Complement* of the Sun's *Meridian Altitude* by Obſervation to be 33 *deg.* 10 *min.* The Latitude of that place the Ship is in is required.

	deg.	*min.*
The diſtance *of the* Sun *from the* Zenith	33	10
North Declination, *add*	16	07
The Latitude *the Ship is in*	49	17

Suppoſe a *Ship* were at Sea the 13*th* of *Sept.* 1683. and I find the *Complement* of the Sun's *Meridian Altitude*, or diſtance from the *Zenith*, 45 *deg.* 58 *min.* I demand what Latitude the *Ship* is in.

	deg.	*min.*
The Zenith-diſtance *of the* Sun	45	58
The Declination South, *ſubtract*	00	07
The Latitude *the Ship is in*	45	51

Admit a *Ship* were at Sea the fourth of *December*, *Anno* 1690. and the *Complement* of the Sun's *Meridian Altitude* that day were 49 *deg.* The Latitude the *Ship* is in, is required.

deg

	degr.	*min.*
The Sun *is diſtant from the* Zenith	49	23
The Sun's Declination *South*, *ſubtract*	23	20
The Latitude *the Ship is in*	26	03

Suppoſe I were in a *Ship* at Sea the 23*d* of *May*, *Anno* 1695, and am alſo in Longitude to the *Eaſt* of the *Meridian* of *London* 135 *deg.* and I find the *Complement* of the *Meridian Altitude* by Obſervation to be 13 *degr.* 28 *min.* The *Latitude* is required.

	degr.	*min.*
Declination *in the* Meridian *of* London	22	17
The Proportional Minutes, *ſubtract*	00	03
The Sun's Declination *in the* Meridian *given*	22	14
The Zenith-diſtance *of the* Sun *ſubtr.*	13	28
The Latitude *the Ship is in*	08	46

Examples in South Latitude.

ADmit a *Ship* at Sea the 7*th* of *July*, *Anno* 1695, and the *Sun* being upon the *Meridian*, I find the *Complement* of his *Meridian Altitude* by Obſervation to be 42 *deg.* 50 *min. North.* The Latitude is demanded.

	degr.	*min.*
The Sun's *diſtance from the* Zenith	42	50
The Declination *North*, *ſubtract*	21	16
The Latitude *the Ship is in*	21	34

Admit I were in a *Ship* the fifth of *November*, *Anno* 1687. and the difference of Longitude from *London* 120 *d. Weſt*, and the *Complement* of the Sun's *Meridian Altitude* by Obſervation is 31 *deg.* 53 *min. North*: the Latitude is required the *Ship* is in.

	deg.	*mi.*	
The Sun's *diſtance from the* Zenith	31	53	
The Declination *South*, at *London*	18	37	
The Proportional Minutes	00	05	*Added.*
The Sun's Declination *in the* Meridian *given*	18	42	
Which adde to the Zenith-diſtance	31	53	
The Latitude *the* Ship is in	50	35	

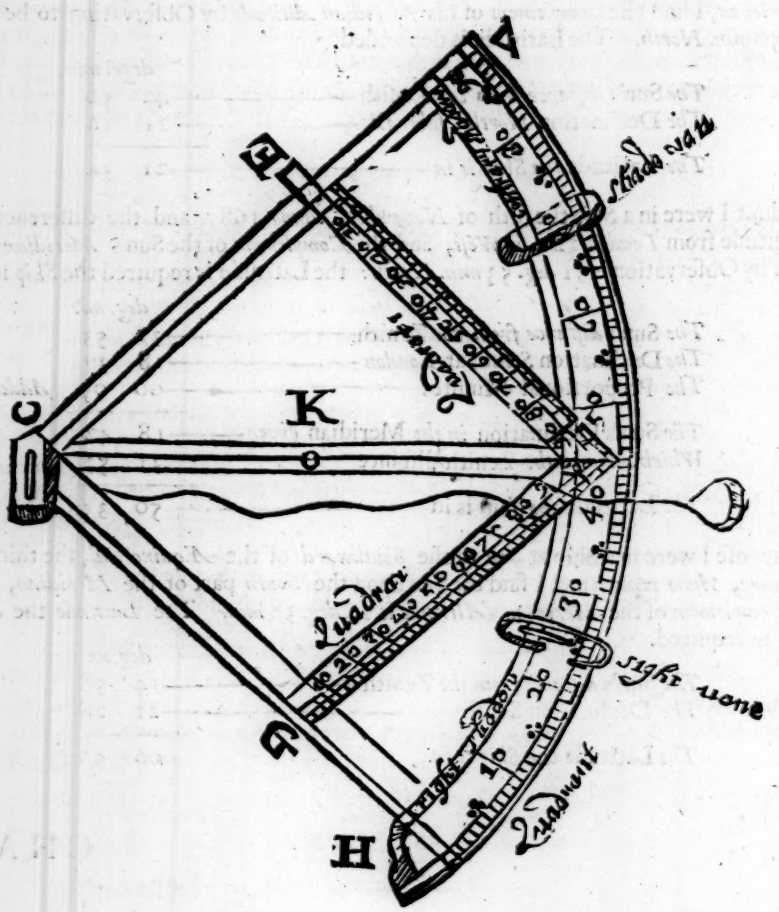
Suppoſe I were in a Ship at *Sea* to the *Southwards* of the *Æquinoctial*, the third of *January*, *Anno* 1683. and I find the *Sun* upon the *South* part of the *Meridian*, and the *Complement* of the *Meridian Altitude* is 14 *deg.* 38 *min.* The *Latitude* the *Ship* is in is required.

	deg.	*min.*
The Sun's *diſtance from the* Zenith	14	38
The Declination South	21	28
The Latitude the *Ship is in.*	06	50

CHAP. XV.

The Description and Use of a Quadrant *for the taking* Altitudes *on* Land *or* Sea, *of the* Sun *or* Stars, *or the* Altitude *of* Hills, Trees, Steeples, *or* Castles, *or any other Object.*

THis *Quadrant* is to be made of well-seasoned and smooth dry *Box* or *Pear-tree*. The *Semidiameter* of the *Quadrant* is about 19 or 20 Inches. The *Arch* of the *Quadrant* is divided into 90 *degrees* first, and each *degree* into 6 *equal parts*, each *part* being 10 *minutes*, which is near enough for *Sea* or *Land Observations*, and numbred as you see from 10 to 90 *deg*. In this *Quadrant* is inscribed the *Quadrat* C E F G, whose *sides* G F and F E are divided into 100 equal parts. On the *side* G F are the *parts* of *Right Shadow*; on the other *side* E F are the *parts* of *Contrary Shadow*. In the *Center* at C there is a *Brass-pin*, on it to hang a *Thread* and *Plummet*; and on one of the sides there is a *Sight* made of *Brass* at E. There is also an *Horizon-Vane*, let in upon the *Center* C, and a *Shade-Vane* and *Sight-Vane*, for *Back-Observation*. The Use of the *Quadrant* is as follows.



EXAMPLE

EXAMPLE.

Admit I am aſhore, and would know the Sun's *Meridian Altitude*, and true *Latitude* of the Place. Take the *Altitude* thus; The *String* and *Plummet* being hanged on the Center C, turn the *Braſs-Pin* to the Sun, and hold up the Center until the *ſhade* of the *Braſs-Pin* ſtrikes on the *Sight* and *line* at E, the *Thred* and *Plummet* playing eaſily by the ſide; mark where it cuts the Arch of the *Quadrant*, as at F, that is the Sun's *Altitude*, and reckoned from H; and the *Latitude* is found by the ſame *Rules* as you have been given in the Uſe of the *Fore-ſtaff*. The beſt way to hold the *Quadrant* ſteady, is to skrew it with a *Braſs-Pin* at K, to a *ſtaff* ſet perpendicular, and then you may raiſe it by degrees, as the Sun riſes.

PROPOSITION I.

For Back-Obſervation *at* Sea.

Take the Handle of the *Quadrant* at H in your hand, after the *Vanes* are ſet on, and fix the *Shade-Vane*; then hold your *Quadrant* upright; then bring your *Sight-Vane* to your Eye, and look through your *Sight* upon the *Horizon-Vane*. You muſt be ſure to hold your *Quadrant* ſo, that the upper part of the *ſhadow* of your *Shade-Vane* may fall upon the upper part of the *ſlit* of your *Horizon-Vane*, and look through the *ſlit* for the *Horizon*: but if you cannot ſee the *Horizon*, but all *Skie* and no *Water*, you muſt put your *Sight-Vane* a little higher towards V; but if, on the contrary, you do ſee all *Water* and no *Skie*, then ſlide your *Sight-Vane* a little lower towards H, and then make Obſervation again; and if the upper part of the *ſhade* do lie upon the upper part of the *ſlit*, and you ſee the *Horizon* at the ſame time, then you have the Sun's preſent *Altitude*, and you muſt wait longer as your judgment informs you, till the Sun is upon the *Meridian*, and obſerve as you did before: and if the Sun be to the *Weſtward* of the *Meridian*, and falling, you will ſee all *skie* and no *water*, and the work is done for that day. Then look what degrees the *Shade-Vane* is put at, which in the *Figure* is at 70 *deg.* which note. Look alſo what *degrees* and *minutes* do ſtand againſt your *Sight-Vane*, which ſubtract from the former *degrees* by the *Shade-Vane*, and the Remainder is the Sun's *Meridian Altitude*, As in the *Figure*, the *Sight-Vane* is at 25 *deg.* 30 *min.* which taken out of 70 *deg.* the Remainder is 44 *deg.* 30 *min.* the Sun's *Altitude*. And the way of working your Obſervation, is the very ſame as you have been given in the Uſe of the *Fore-ſtaff*.

PROP. II.

To find whether a place be level with the Eye, *or not.*

TAke the *Quadrant*, and look through the *Sight* at E, by the *Center-pin* C, unto the place you would know whether it be level, or not. If the *Thred* fall on CH, then is the Place level with the *Eye*; but if it ſhould fall within, upon any of the *Diviſions*, then it is higher; if without the *Quadrant*, then it is lower than the level of the *Eye*.

PROP. III.

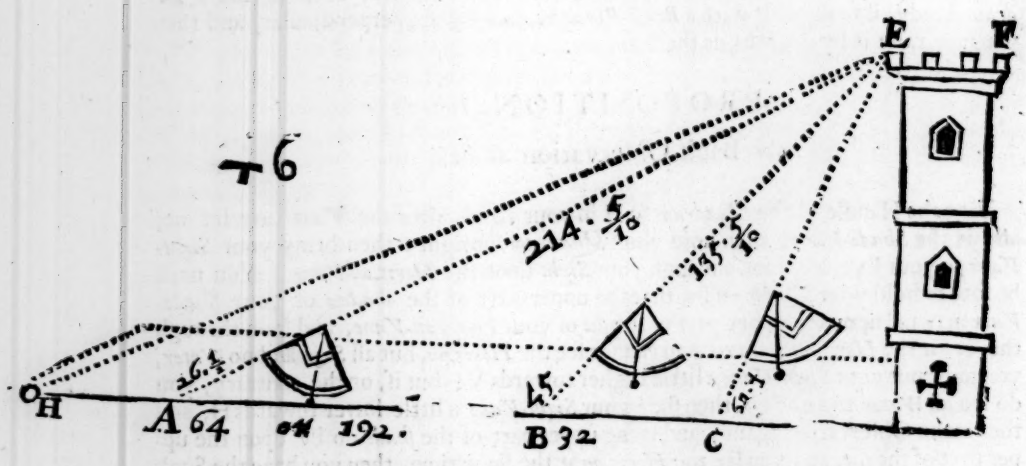
To find the Height *of an* Houſe, Steeple, Tower, *or* Tree, *from the Ground at one Obſervation.*

IF you can approach the foot of the Object whoſe *Height* you deſire, the thing is eaſily performed by this *Quadrant*; hold up your *Quadrant* to the place whoſe *Height* you would know, and looking through the *Sight* on the ſide EC, going nearer or further from it till the *Thred* cut 45 *degrees*, or fall upon 100 *Parts* in the

the *Quadrat*: ſo ſhall the *Height* of the Object above the level of your *Eye*, be equal to the *Diſtance* between the *Place* and your *Eye*.

If the *Thred* fall on 50 *parts* of the right *ſhadow*, the *Height* is but half the *Diſtance*. If the *Thred* cut 25 *parts* of right *ſhadow*, it is but a quarter of the *Diſtance*; but if it fall on 75 *parts*, it is three quarters of the *Diſtance*. The *Rule* is,

As 100, *to the* Parts *on which the* Thred *falleth*;
So is the Diſtance *to the* Height *required*.



But when the *Thred* ſhall fall on the parts of the contrary *ſhadow*, then if it fall on 50 *Parts*, the *Height* is double unto the *Diſtance*. If on 25, it is four times the *Diſtance*. If the *Thred* fall upon the contrary *ſhadow*, this is the *Rule*.

As the Parts *cut by the* Thred, *are unto* 100:
So is the Diſtance *unto the* Height.

PROP. IV.

The Diſtance *being given to find the* Altitude *at two Stations.*

SUppoſe E D were a *Tower* or *Steeple*, whoſe *Altitude* you would know, and you cannot come ſo near as to meaſure between your *Station* of 45 *deg.* and the *Baſe* of the Object, by reaſon of ſome *Wall* or *Moat*; yet by the proportion of the *Line* of *Quadrature*, you may help your ſelf by another *Station*.

Thus if you could not meaſure the *Diſtance* from B to D, then go backward from B to A, until the *Thred* cut the 26 *deg.* 30 *min.* of your *Quadrant*; and meaſure the *Diſtance* between B and A: as ſuppoſe it to be 32 *Foot* or *Yards*, which is equal to the *Height* D E 32; the whole *Line* D A being 64 *Feet* or *Yards*, double to the *Height*.

But if you cannot come ſo near the Foot of the Object as to make an Angle of 45 *deg.* then take two other convenient *ſtations*, and obſerve the two *Angles* at thoſe *ſtations*, meaſuring the *Diſtance* between the *ſtations*. Then ſubtract the greater of the two *Angles* from 180 *deg.* and to the Remainder add the leſſer *Angle* obſerved, and ſubtract that *ſum* from 180 *deg.* and note this Remainder. Then ſay,

As the Sine *of the laſt remaining* Angle,
To the Diſtance *between the two* ſtations:
So is the Sine *of the leſſer* Angle *obſerved*,
To a fourth Number. And

As

As this fourth Number, *to* Radius:
So is the Sine *of the* greater Angle obſerved, *to the* Height *of the* Object *required.*

EXAMPLE.

Suppoſe the Angle at the *firſt Station* to be 43 *degr.* 50 *min.* and the Angle at the *ſecond Station* to be 30 *deg.* 58 *m.* and the *Diſtance* betwixt the *two ſtations* 60 *Yards:* to find the *Altitude* of the Object above the Level of the *Eye.* The *greater Angle* ſubtracted from 180 *deg.* leaves 136 *deg.* 10 *m.* to which adding the *leſſer Angle,* the Sum is 166 *deg.* 08 *min.* which ſubtracted from 180 *deg.* leaves 12 *deg.* 52 *min.*
Then,

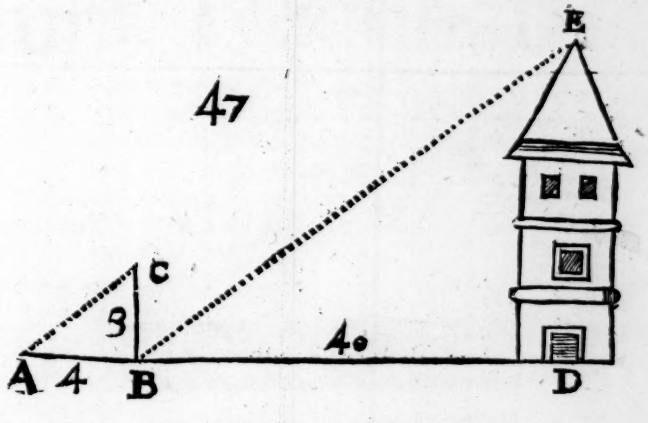
As Sine 12 *deg.* 52 *min.*
To the Diſtance *of the* two Stations, 60 Yards.
So is the Sine *of the* leſſer Angle, 30 *deg.* 58 *min.*
To a fourth Number, *which is* 138 Yards.

Then, *As the* fourth Number, 138 Yards,
To Radius:
So the Sine *of the* greater Angle, 43 *deg.* 50 *min.*
To the Altitude *required,* 95 Yards $\frac{1}{10}$.

PROP. V.

By the Height *of the* Sun, *and the* Length *of the* Shadow, *to find the* Height *of any* Tree, Tower, *or* Steeple.

This Concluſion may be tried by a little *Quadrant,* by which you may take the *Sun's Altitude* to $\frac{1}{2}$ or $\frac{1}{4}$ of a Degree, which is near enough for theſe Concluſions.



Suppoſe D E to be a *Turret,* or *Steeple,* whoſe *Height* is required to be found by the *ſhadow* it makes on Level Ground, the *Rule* is thus, *viz.* Let the *Height* of the *Sun* be 37 *deg.* 00 *min.* and the *Length* of the *ſhadow* 40 *Foot,* the *Rule* is,

As the Radius 90 *deg.* —— 10
To the Length *of the* Shadow 40 Foot —— 160206
So is the Tangent *of the* Sun's Height 37 *deg.* —— 987711
To the Height *of the* Thing *deſired* —— 147917

 which

which is found to be 30 $\frac{14}{100}$ *Parts*, which ſhews the *Height* to be a little above 30 *Foot*.

Here is another way to do the ſame without the help of a *Quadrant*, *viz.* Set up a *Staff* of any Length, ſuppoſe 3 *Feet*, as CB, and the *Shadow* which it makes from B to A is 4 *Feet*; and becauſe the *ſhadow* of the *Tower* from the *Baſe* thereof to B is 40 *Feet*, I ſay,

As the Shadow *of the* Staff, *is to the* Height *of the* Staff:
So is the Shadow *of the* Steple, *to the* Height *of the* Steeple.

The *Operation* may be performed by *Natural Numbers*, or by *Logarithms*, thus, *viz.*

As 4 Feet, *to* 3 : *ſo* 40 Feet *to* 30 Feet.

$$\frac{3}{4} \times 40 = 30$$

As the Shadow *of the* Staff 4 Feet A B, Log. ——	0,60206
To the Length *of the* Staff 3 Feet B C ——	0,47712
So is the Shadow *of the* Steeple 40 Feet DB ——	1,60206
	2,47918
To the Height *of the* Tower 30 Feet DE ——	1,47712

A

Constant Kalendar:

OR AN

ALMANACK,

SHEWING THE

Primes, *Epacts*, *Dominical Letter*, and *Moveable Feasts*, the Hour of *Sunsetting* each Day in the Year.

WITH EXACT

TABLES

OF THE

Suns Declination.

BY

Capt. SAMUEL STURMY.

LONDON,

Printed in the Year 1677.

A

Conftant Kalendar:

OR AN

ALMANACK,

SHEWING THE

Primes, Epact, Dominical Letter, and Moveable

Feafts, the Hour of Sun-rifing each Day in

the Year.

WITH MANY

TABLES

OF THE

Sun's Declination.

BY

Capt. SAMUEL SHARPE.

LONDON:

Printed in the Year 1679.

AN ALMANACK For *XXXII* Years, According to the *Engliſh* and *Foreign Accounts*.

Anno Dom.	*Prime.*	*Epact.*	*Sund. Lett.*	*Shrove Sunday.*	*Eaſter Sunday.*	*Whit-Sunday.*
1664	12	12	CB	Feb. 21	10	May 29
1665	13	23	A	5	March 26	14
1666	14	04	G	25	April 15	June 3
1667	15	15	F	17	7	May 26
1668	16	26	ED	2	March 22	10
1669	17	7	C	21	April 11	30
1970	18	18	B	13	3	22
1671	19	29	A	March 05	23	June 11
1672	01	11	GF	Feb. 18	7	May 26
1673	2	22	E	9	March 30	18
1674	3	3	D	March 1	April 19	June 7
1675	4	14	C	Feb. 14	4	May 23
1676	5	25	BA	6	March 26	14
1677	6	6	G	25	April 15	June 03
1678	7	17	F	10	March 31	May 19
1679	8	28	E	March 2	April 20	June 08
1680	9	9	DC	Feb. 22	11	May 30
1681	10	20	B	13	3	22
1682	11	1	A	26	16	June 04
1683	12	12	G	18	8	May 27
1684	13	23	FE	10	March 30	18
1685	14	4	D	March 1	April 19	June 07
1686	15	15	C	Feb. 14	4	May 23
1687	16	26	B	6	March 27	15
1688	17	7	AG	26	April 15	June 03
1689	18	18	F	10	March 31	May 15
1690	19	20	E	March 2	April 20	June 08
1691	1	11	D	Feb. 22	April 12	May 31
1692	2	22	CB	7	March 27	May 15
1663	3	3	A	Feb. 26	April 16	June 4
1694	4	14	G	18	8	May 27
1695	5	25	F	Feb. 3	March 24	12

The Uſe of the Almanack *for* 32 Years.

THis *Table* ſheweth firſt the *Date* of the *Years*; ſecondly, the *Prime*, or *Golden Number*; thirdly, the *Epact*; fourthly, the *Dominical Letter* for theſe Years; and then in their Order the chief *Moveable Feaſts*, (viz.) *Shrove-ſunday*, *Eaſter-day*, and *Whit-ſunday*, upon which all the reſt depend. The *Foreign Account* is commonly ten days before us.

Of the Terms.

THere are four times of the Year appointed for the *determining* of *Cauſes*, theſe are called *Terms*. Two of theſe *Terms*, viz. *Hillary Term*, and *Michaelmas Term*, are at a conſtant time of the Year; but *Eaſter Term* and *Trinity Term* are ſooner or later, as thoſe *Feaſts* happen. Each of theſe *Terms* hath ſeveral *Returns*, and each *Return* hath four *days* belonging to it. The firſt is the *Day* of *Return* or *Eſſoin*, for the *Defendant* in a *Perſonal Action*, or the *Tenant* in a *Real Action*. The ſecond is the *Day* of *Exception*, for the *Plaintiff* or *Defendant* to lay an *Exception*. The third is the *Day* whereon the *Sheriff* muſt return the *Writ*. The fourth is the *Day* of *Appearance* in the *Court*. Theſe four *Days* follow each other in order, except a *Sunday* or *Holyday* take up any of them, and then the *Day* following ſerves for both Occaſions.

The Beginning and End of *Hillary Term* and *Michaelmas Term*, with all their *Returns*, you ſhall find in this following *Kalendar*, which are conſtant if no *Sunday* hinder them.

Eaſter Term begins *Wedneſday* Fortnight or 17 Days after *Eaſter*, and ends the *Munday* after *Holy Thurſday*, or the *Munday* before *Whitſunday*. It hath theſe five *Returns*.

Quind.

Quind. Pasc. A Fortnight
Tref. Pasc. Three Weeks
Mens. Pasc. A Month
Quinq. Pasc. Five Weeeks
} after *Easter*.
Crast. Ascen. The Day after *Holy Thursday*.

Trinity Term begins the *Friday* after *Trinity-Sunday*, which is next Sunday to *Whitsunday*, and hath these four *Returns*.

Crast. Trin. The *Munday* after *Trinity-Sunday*.
Oct. Trin. A Week after *Trinity-Sunday*.
Quind Trin. A Fortnight after *Trinity-Sunday*.
Tref. Trin. Three Weeks after *Trinity-Sunday*.

The *Exchequer* opens four Days before *Trinity Term*; but eight Days before the other *Terms*.

Lo! here a Trade *surpaseth all the rest*;
No Change *annoys the* Lawyer's Interest.
His Tongue *buyes* Lands, *builds* Houses, *without Toil*;
The Pen's *his* Plough, *the* Parchment *is his* Soil;
Him Storms *disturb not, nor* Militia Bands.
The Tree *roots best, that in the* Weather *stands*.

How to Rectifie the *Tables* of the *Sun*'s *Declination* at any time by *Prosthaphæreses*.

The Use of the Table.

THE *Sun*'s *Declination* in this *Kalendar* is Calculated for the Years 1665, 66, 67, and 68. but for any Year after 1668, the *Rule* is thus.

For Example. I would know the Sun's *Declination* for the year 1689. you must always subtract 1668 from the year given, which is here 1689, the Remainder is 21 years; which being divided by 4, the *Quotient* is 5 *Leap-Years*, and 1 remains, which sheweth it is the first Year after *Leap-Year*.

When the Declination increaseth, then add; and for decreasing subtract.

Now I desire to rectifie the *Table* for the first day of *April*, which in the *Kalendar* you have 8 *deg.* 39 *min.* and in this *Table* you have 40 *Seconds*; which multiplied by 5 *Leap-Years*, give 200 *seconds*, that is 3 *min.* 20 *sec.* to be added to 8 *deg.* 39 *min.* So you have 8 *deg.* 42 *m.* for the Sun's *Declination* in 1689.

Prosthaphæreses *of the* Sun's Declination.

Day Month.	Jan. Sec.	Feb. Sec.	Mar. Sec.	Apr. Sec.	May. Sec.	Jun Sec.	July. Sec.	Aug. Sec.	Sept. Sec.	Octob. Sec.	Nov. Sec.	Dec. Sec.
1	17	36	42	40	28	8	15	33	42	41	30	9
2	18	37	43	39	28	7	15	34	43	42	29	8
3	19	37	43	40	27	6	16	35	43	42	29	7
4	20	38	44	40	27	5	17	35	43	42	28	6
5	20	37	44	39	26	4	18	34	43	41	28	5
6	21	37	43	39	25	4	19	35	43	41	28	4
7	21	38	43	38	25	3	19	35	44	41	27	3
8	22	39	43	38	24	2	19	35	43	40	26	2
9	24	38	44	38	23	2	20	36	44	40	25	1
10	24	39	45	37	23	1	21	36	43	40	24	1
11	25	39	44	37	22	0	21	37	43	40	24	0
12	25	40	44	37	22	1	22	38	43	39	23	0
13	26	41	43	37	21	1	22	38	43	39	22	1
14	26	40	44	37	20	2	23	38	44	38	21	2
15	27	41	44	35	20	3	23	38	43	38	21	3
16	28	42	43	35	19	4	24	39	44	37	20	4
17	28	41	42	35	19	4	25	39	43	38	20	5
18	29	41	43	35	18	5	26	39	43	37	19	6
19	30	41	43	34	17	6	26	39	43	37	18	7
20	31	42	42	34	17	7	27	40	43	36	17	8
21	31	42	43	33	16	8	27	40	43	36	16	9
22	32	42	43	33	15	8	28	41	44	35	16	10
23	32	43	43	32	14	9	29	40	43	35	15	11
24	32	43	42	32	14	10	29	41	42	34	14	12
25	33	44	42	31	12	11	30	41	43	34	13	12
26	33	44	41	31	12	12	30	41	42	33	13	13
27	34	43	41	30	11	13	30	41	42	34	12	14
28	35	43	41	29	9	14	31	41	43	32	11	16
29	35	43	41	29	9	14	31	41	43	32	11	16
30	35		41	29	9	14	32	42	42	32	10	16
31	36		41		8		33		31		17	

A Table

A Table of the Sun's Declination.

JANUARY XXXI.

Day Mo.	Day Week	D. Epact.	Hour Dif.	☉ Rising and Sett.	Leap ye. 1664 1668 1672 1676 1680 1684 1688 1692 Deg.	Min.	Differ.	First. 1665 1669 1673 1677 1681 1685 1689 1693 Deg.	Min.	Second. 1666 1670 1674 1678 1682 1686 1690 1694 Differ. Deg.	Min.	Third. 1667 1671 1675 1679 1683 1687 1691 1695 Differ. Deg.	Min.	Differ.
1	A	29		Circumcis.	21	50		21	43		21	45		21	47	
2	B	28	0	4 1 8	21	49	10	21	33	10	21	35	10	21	38	9
3	C	26	12	4 2 8	21	30	10	21	22	11	21	25	10	21	28	10
4	D	25	08	4 3 8	21	20	10	21	11	11	21	14	11	21	17	11
5	E	23	21	4 4 8	21	09	11	21	00	11	21	03	11	21	06	11
6	F	✶	1	Twelf-day	20	57	12	20	48	12	20	51	12	20	54	12
7	G	22	10	4 7 8	20	45	12	20	36	12	20	39	12	20	42	12
8	A	21		4 8 8	20	33	12	20	24	12	20	27	12	20	30	12
9	B	20	06	☉ in ♒.	20	21	12	20	11	13	20	14	13	20	17	13
10	C	18	18	4 11 8	20	8	12	19	58	13	20	01	13	20	04	13
11	D	✶	1	4 12 8	19	55	13	19	44	14	19	48	14	19	51	13
12	E	17	15	4 14 8	19	41	14	19	30	14	19	33	14	19	37	14
13	F	16		Hilary.	19	27	14	19	16	14	19	19	14	19	23	14
14	G	15	03	4 11 8	19	12	15	19	01	15	19	04	15	19	08	15
15	A	✶		4 18 8	18	57	15	18	46	15	18	50	14	18	54	14
16	B	14	0	4 20 8	18	42	15	18	31	15	18	35	15	18	39	15
17	C	12	12	4 21 8	18	27	15	18	15	16	18	19	16	18	23	16
18	D	✶		4 23 8	18	11	16	17	59	16	18	03	16	18	07	16
19	E	11	1	☉ 10 ♒.	17	55	16	17	42	17	17	47	16	17	51	16
20	F	9	0	Oct. Hilar.	17	38	17	17	26	16	17	30	17	17	34	17
21	G	7	10	Except.	17	22	16	17	9	17	17	13	17	17	17	17
22	A	✶		Ret. Brev.	17	5	17	16	51	18	16	56	17	17	00	17
23	B	6	6	Term. beg.	16	47	18	16	34	17	16	38	18	16	42	18
24	C	4	18	4 23 8	16	30	17	16	16	18	16	20	18	16	25	17
25	D	✶		Conv. Paul.	16	12	18	15	58	18	16	02	18	16	07	18
26	E	3	7	4 27 8	15	54	18	15	40	18	15	44	18	15	49	18
27	F	2	0	Q. Hilar.	15	35	19	15	21	19	15	25	19	15	30	19
28	G	1	3	Except.	15	16	19	15	2	19	15	07	18	15	11	19
29	A	✶		Ret. Brev.	14	57	19	14	43	19	15	48	19	14	52	19
30	B	29	16	Appear.	14	38	19	14	22	21	14	28	20	14	33	19
31	C	28	12	4 46 8	14	18	20	14	4	28	14	08	20	14	13	20

South Declinatio. North Declination.

A Table

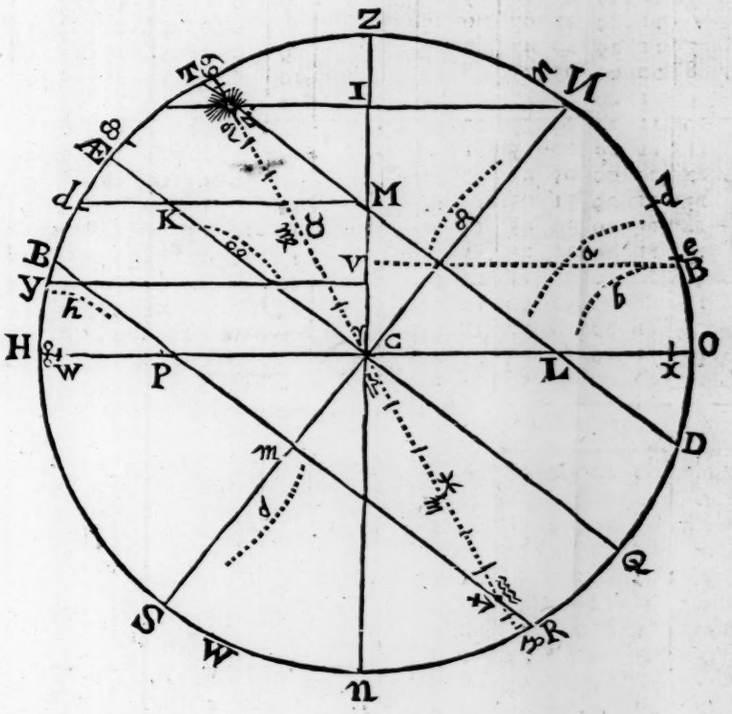
A Table *of the* Sun's Declination.

FEBRUARY. XXVIII.

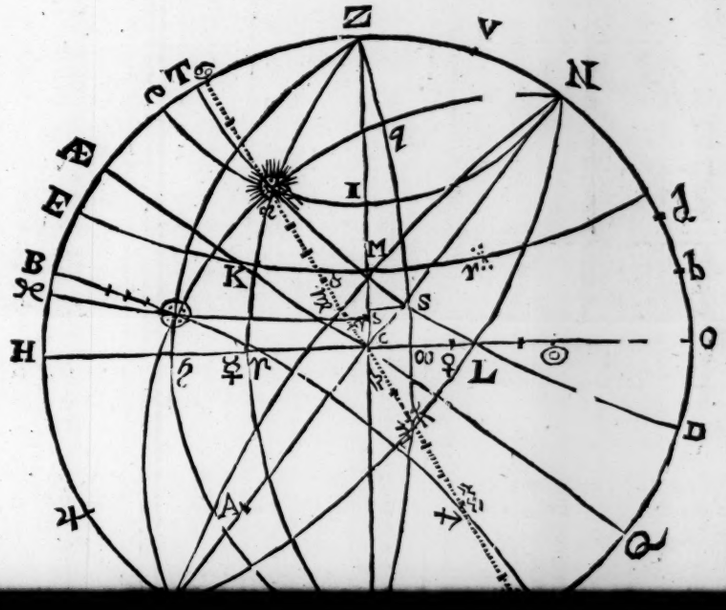
Day Mo.	Da. Week	D Epact.	Hour.	☉ Rising. and Sett.	Leap ye. 1664 1668 1672 1676 1680 1684 1688 1692 Deg.	Min.	Differ.	First. 1665 1669 1673 1677 1681 1685 1689 1693 Deg.	Min.	Second. 1666 1670 1674 1678 1682 1686 1690 1694 Deg. Differ.	Min.	Third. 1667 1671 1675 1679 1683 1687 1691 1695 Degr. Differ.	Min.	Differ.	South Declination.
1	D	27		4 18 8	13	59		13	44	13	48	13	53		
2	E	26	1	Purif. Mar.	13	39	20	13	24	20 13	28	20 13	33	20	
3	F	25		*Craft. Pur.*	13	10	20	13	3	21 13	8	20 13	13	20	
4	G	23	10	*Except.*	12	58	22	12	43	20 12	48	20 12	52	21	
5	A	22	22	*Ret. Brev.*	12	38	20	12	22	21 12	27	21 12	32	20	
6	B	21		*Appear.*	12	17	21	12	1	21 12	6	21 12	11	21	
7	C	20	18	4 59 8	11	56	21	11	40	21 11	45	21 11	50	21	
8	D	19		☉ in ♓.	11	35	21	11	19	21 11	24	21 11	29	21	
9	E	18	8	*Oct. Pur.*	11	14	21	10	57	22 11	2	22 11	8	21	
10	F	18	18	*Except.*	10	52	22	10	36	21 10	40	22 10	47	21	
11	G	17	3	*Ret. Brev.*	10	30	22	10	14	22 10	19	21 10	24	23	
12	A	15	16	Term. ends	10	8	22	9	52	22 9	57	22 10	2	22	
13	B	✱		5 11 7	9	46	22	9	30	22 9	35	22 9	40	22	
14	C	14	12	Valentine.	9	24	22	9	7	23 9	13	22 9	18	22	
15	D	13		5 14 7	9	2	22	8	45	22 8	50	23 8	55	23	
16	E	12	1	5 16 7	8	39	22	8	22	23 8	27	23 8	33	22	
17	F	11	14	5 18 7	8	17	23	8	0	22 8	5	22 8	11	22	
18	G	9	10	☉ 10 ♓.	7	54	23	7	37	23 7	42	23 7	44	22	
19	A	8		5 22 7	7	31	23	7	14	23 7	20	22 7	26	20	
20	B	7	0	5 24 7	7	8	23	6	51	23 6	57	23 7	3	25	
21	C	6	19	5 26 7	6	45	23	6	28	24 6	34	23 6	39	24	
22	D	5		5 28 7	6	22	23	6	4	23 6	10	24 6	16	23	
23	E	4	7	5 30 7	5	59	23	5	41	23 5	47	23 5	53	23	
24	F	3	20	Matthew.	5	36	23	5	18	23 5	24	23 5	30	23	
25	G	2		5 34 7	5	12	24	4	55	24 5	0	24 5	5	25	
26	A	1	16	5 36 7	4	49	23	4	31	23 4	37	23 4	43	22	
27	B	✱		5 38 7	4	25	24	4	8	24 4	13	24 4	19	24	
28	C	29	5	☉ 20 ♓.	4	2	23	3	44	3	50	23 3	56	23	
					3	39	23								

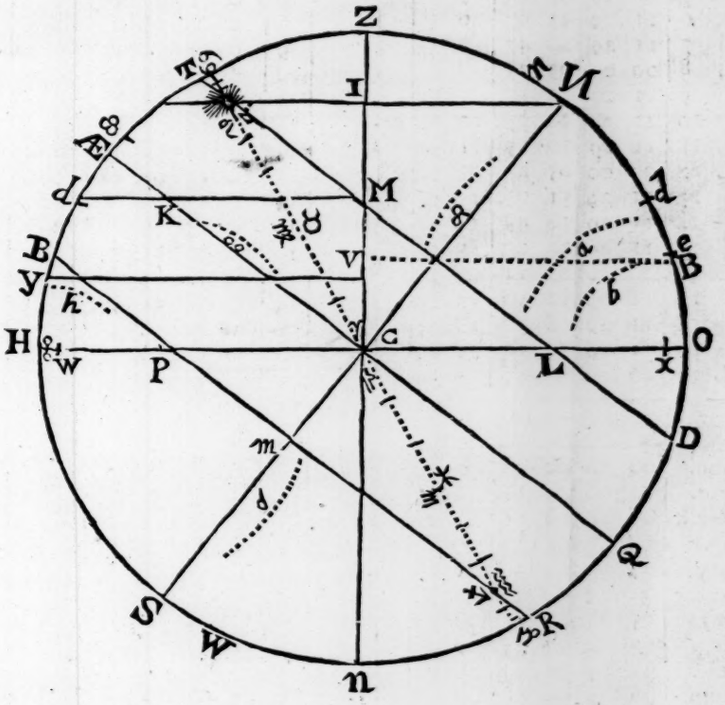
South Declinatio.

The Projection by the Analemma appertaining to the thirteen Problems following.

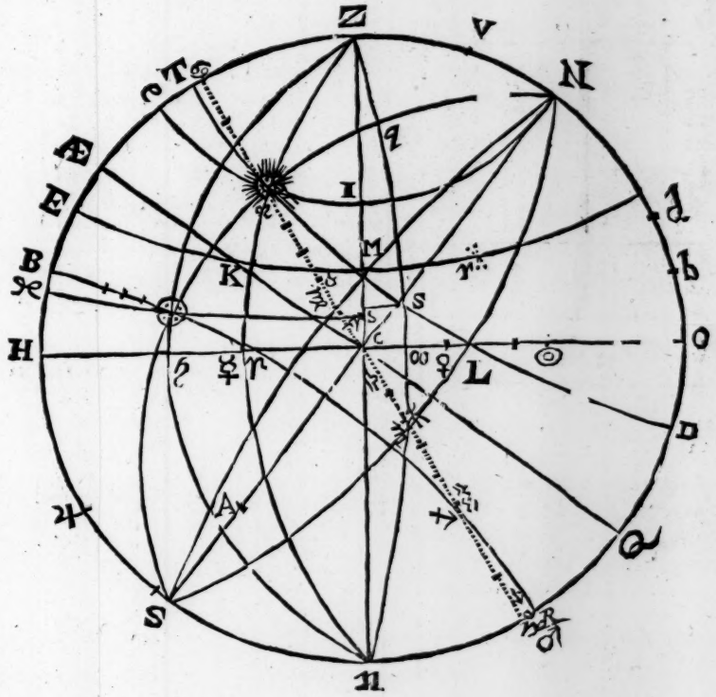


The Stereographick Projection appertaining to the thirteen Problems following.





The Stereographick Projection appertaining to the thirteen Problems following.



A Table of the Suns Mean Motion.

The Epocha or Radix.

Year.	Longit. ☉ S	D	M	S	Apog. ☉ S	D	M	S
Ch. 1	9	07	59	51	2	08	20	03
1581	9	19	48	55	3	05	22	55
1601	9	19	57	54	3	05	43	28
1621	9	20	06	52	3	06	04	00
1641	9	20	15	51	3	06	24	33
1661	9	20	24	49	3	06	45	05
1681	9	20	33	48	3	07	05	38

☉ Mean Motion in Years above 20.

20	0	00	08	59	0	00	20	33
40	0	00	17	57	0	00	41	05
60	0	00	26	56	0	11	01	38
80	0	00	35	54	0	11	22	10
100	0	00	44	53	0	11	42	43
200	0	01	29	45	0	03	25	26
300	0	02	14	38	0	05	08	08
400	0	02	59	31	0	06	50	51
500	0	03	44	23	0	08	33	34
600	0	04	29	16	0	10	16	17
700	0	05	14	09	0	11	59	00
800	0	05	59	01	0	13	41	42
900	0	06	43	54	0	15	24	25
1000	0	07	28	47	0	17	07	08
2000	0	14	57	34	1	04	14	15
3000	0	22	26	21	1	21	21	22
4000	0	29	55	08	2	08	28	30
5000	1	07	23	55	2	25	35	37
6000	1	14	52	42	3	12	42	44

☉ Mean Motion in years under 20

	Years.	Longit. ☉ S	D	M	S	Apo. ☉ M	S
	1	11	29	45	40	1	02
	2	11	29	31	20	2	04
	3	11	29	16	59	3	05
L	4	00	00	01	48	4	07
	5	11	29	47	28	5	08
	6	11	29	33	07	6	10
	7	11	29	10	47	7	12
L	8	00	00	03	35	8	13
	9	11	29	49	15	9	14
	10	11	29	34	55	10	16
	11	11	29	20	35	11	17
L	12	00	00	05	23	12	20
	13	11	29	51	03	13	21
	14	11	29	36	43	14	23
	15	11	29	22	23	15	25
L	16	00	00	07	11	16	26
	17	11	29	52	51	17	28
	18	11	29	38	31	18	29
	19	11	29	24	10	19	31
L	20	00	00	08	59	20	33

☉ Mean Motion in Months.

Janu.	00	00	00	00	00	00
Febr.	01	00	33	18	00	05
March	01	28	09	11	00	10
April	02	28	42	30	00	15
May	03	28	16	39	00	20
June	04	28	49	58	00	25
July	05	28	24	07	00	31
Aug.	06	28	57	25	00	36
Sept.	07	29	30	44	00	42
Octo.	08	29	04	54	00	47
Nov.	09	29	38	12	00	53
Dec.	10	29	12	22	00	59

The Calculation.

	Longit. ☉ S	D	M	S	Apog. ☉ S	D	M	S
The Epocha.								
1581.	9	19	48	55	3	5	22	55
Years added 2	11	29	31	20			2	4
March.	1	28	9	11				10
Days 13		12	48	49				2
Hours 23			56	40				0
Minutes 8				20				0
The Suns Mean Motion.	0	1	15	15	3	5	25	11
Apogeum Subtract.	3	5	25	11				
The Anomaly of ☉	8	25	50	04				
The Equat. added to the Mean Mot.		2	2	51				
Gives the Suns true place,	♈	3	18	6				
Agreeing with the Obſervation.	♈	3	17	40				

(3) Example, the time given the 10 of *April* 1665 at Noon; and by the former Rules we have found the Suns Mean Motion 29 *deg.* 0 *min.* 30″, his Apogeum 3 *s.* 6 *d.* 49 *m* 29″, his Anomaly 9 *s.* 22 *d.* 11 *m.* 1″. And to find a Propor. part for the Equat. proceed thus: the Equat. anſwering to 22 *d.* is 1 *d.* 52 *m.* 22; the Equator anſwer. to 23 *d.* is 1 *d.* 51 *m.* 29

A Table of the Suns Mean Motion.

Days	Longit. ☉ S	D	M	S	Apo. M	S	H	Long. ☉ D	M	S	M	Lon. ☉ M	S
1	0	0	59	08	0	0	1	0	2	28	31	1	17
2	0	01	58	17	0	0	2	0	4	56	32	1	19
3	0	02	57	25	0	0	3	0	7	24	33	1	21
4	0	03	56	33	0	1	4	0	9	51	34	1	24
5	0	04	55	42	0	1	5	0	12	19	35	1	26
6	6	05	54	50	0	1	6	0	14	47	36	1	29
7	0	06	53	58	0	1	7	0	17	15	37	1	31
8	0	07	53	07	0	1	8	0	19	43	38	1	34
9	0	08	52	15	0	1	9	0	22	11	39	1	36
10	0	09	51	23	0	2	10	0	24	38	40	1	39
11	0	10	50	31	0	2	11	0	27	6	41	1	41
12	0	11	49	40	0	2	12	0	29	34	42	1	43
13	0	12	48	49	0	2	13	0	32	2	43	1	46
14	0	13	47	57	0	2	14	0	34	30	44	1	48
15	0	14	47	05	0	2	15	0	36	58	45	1	51
16	0	15	46	13	0	3	16	0	39	25	46	1	53
17	0	16	45	22	0	3	17	0	41	53	47	1	56
18	0	17	44	30	0	3	18	0	44	21	48	1	58
19	0	18	43	38	0	3	19	0	46	49	49	2	01
20	0	19	42	47	0	3	20	0	49	17	50	2	03
21	0	20	41	55	0	3	21	0	51	45	51	2	06
22	0	21	41	03	0	4	22	0	54	13	52	2	08
23	0	22	40	12	0	4	23	0	56	40	53	2	11
24	0	23	39	20	0	4	24	0	59	8	54	2	13
25	0	24	38	28	0	4	25	1	01	36	55	2	16
26	0	25	37	37	0	4	26	1	04	04	56	2	18
27	0	26	36	45	0	4	27	1	06	32	57	2	20
28	0	27	35	53	0	5	28	1	09	00	58	2	23
29	0	28	35	02	0	5	29	1	11	27	59	2	25
30	0	29	34	10	0	5	30	1	13	55	60	2	28
31	0	00	33	18	0	5	M	*m.*	*ſc.*	*th.*	*ſc.*	*ſc.*	*th.*

A Table of the Suns Equation.

	Sig. 0 Sub. D	M	S	Sig. 1 Sub. D	M	S	Sig. 2 Sub. D	M	S	Sig. 3 Sub. D	M	S	Sig. 4 Sub. D	M	S	Sig. 5 Sub. D	M	S	
0	0	0	0	0	59	32	1	44	28	2	2	54	1	48	23	1	3	26	30
1	0	2	5	1	1	21	1	45	34	2	2	56	1	47	20	1	1	32	29
2	0	4	9	1	3	10	1	46	38	2	2	56	1	46	15	0	59	37	28
3	0	6	12	1	4	57	1	47	41	2	2	55	1	45	9	0	57	40	27
4	0	8	16	1	6	42	1	48	40	2	2	52	1	44	1	9	55	42	26
5	0	10	19	1	8	26	1	49	38	2	2	47	1	42	50	0	53	43	25
6	0	12	22	1	10	9	1	50	34	2	2	39	1	41	37	0	51	43	24
7	0	14	25	1	11	51	1	51	29	2	2	29	1	40	22	0	49	42	23
8	0	16	28	1	13	32	1	52	22	2	2	17	1	39	4	0	45	39	22
9	0	18	30	1	15	11	1	53	13	2	2	2	1	37	45	0	45	35	21
10	0	20	32	1	16	49	1	54	1	2	1	46	1	36	24	0	43	31	20
11	0	22	34	1	18	26	1	54	43	2	1	29	1	35	3	0	41	26	19
12	0	24	37	1	20	02	1	55	31	2	1	7	1	33	39	0	39	20	18
13	0	26	39	1	21	36	1	56	14	2	0	44	1	32	2	0	37	14	17
14	0	28	41	1	23	9	1	56	55	2	0	18	1	30	44	0	35	6	16
15	0	30	42	1	24	41	1	57	34	1	59	49	1	29	13	0	32	58	15
16	0	32	43	1	26	11	1	58	10	1	59	19	1	27	41	0	30	50	14
17	0	34	44	1	27	40	1	58	44	1	58	47	1	26	7	0	28	41	13
18	0	36	43	1	29	8	1	59	16	1	58	12	1	24	32	0	26	31	12
19	0	38	41	1	30	34	1	59	46	1	57	35	1	22	56	0	24	21	11
20	0	40	38	1	31	58	2	0	14	1	56	56	1	21	18	0	22	10	10
21	0	42	35	1	33	20	2	0	40	1	56	14	1	19	38	0	19	59	9
22	0	44	31	1	34	41	2	1	04	1	55	30	1	17	56	0	17	48	8
23	0	46	27	1	36	0	2	1	26	1	54	44	1	16	12	0	15	36	7
24	0	48	22	1	37	17	2	1	46	1	53	56	1	14	26	0	13	33	6
25	0	50	16	1	38	33	2	2	3	1	53	5	1	12	40	0	11	19	5

1621	9	20	06	52	3	06	04	00
1641	9	20	15	51	3	06	24	33
1661	9	20	24	49	3	06	45	05
1681	9	20	33	48	3	07	05	38

☉ Mean Motion in Years above 20.

20	0	00	08	59	0	00	20	33
40	0	00	17	57	0	00	41	05
60	0	00	26	56	0	11	01	38
80	0	00	35	54	0	11	22	10
100	0	00	44	53	0	11	42	43
200	0	01	29	45	0	03	25	26
300	0	02	14	38	0	05	08	08
400	0	02	59	31	0	06	50	51
500	0	03	44	23	0	08	33	34
600	0	04	29	16	0	10	16	17
700	0	05	14	09	0	11	59	00
800	0	05	59	01	0	13	41	42
900	0	06	43	54	0	15	24	25
1000	0	07	28	47	0	17	07	08
2000	0	14	57	34	1	04	14	15
3000	0	22	26	21	1	21	21	22
4000	0	29	55	08	2	08	28	30
5000	1	07	23	55	2	25	35	37
6000	1	14	52	42	3	12	42	44

	3	11	29	16	59	3	05
L	4	00	00	01	48	4	00
	5	11	29	47	28	5	05
	6	11	29	33	07	6	10
	7	11	29	10	47	7	12
L	8	00	00	03	35	8	13
	9	11	29	49	15	9	16
	10	11	29	34	55	10	18
	11	11	29	20	35	11	21
L	12	00	00	05	23	12	20
	13	11	29	51	03	13	21
	14	11	29	36	43	14	23
	15	11	29	22	23	15	25
L	16	00	00	07	11	16	20
	17	11	29	52	51	17	28
	18	11	29	38	31	18	29
	19	11	29	24	10	19	31
L	20	00	00	08	59	20	33

☉ Mean Motion in Months.

Janu.	00	00	00	00	00	00
Febr.	01	00	33	18	00	05
March	01	28	09	11	00	10
April	02	28	42	30	00	15
May	03	28	16	39	00	20
June	04	28	49	58	00	25
July	05	28	24	07	00	31
Aug.	06	28	57	25	00	36
Sept.	07	29	30	44	00	42
Octo.	08	29	04	54	00	47
Nov.	09	29	38	12	00	53
Dec.	10	29	12	22	00	59

The Calculation. Apog. ☉

	Longit. ☉ S	D	M	S	S	D	M	S
The Epocha.								
1581.	9	19	48	55	3	5	22	55
Years added 2	11	29	31	20			2	4
March.	1	28	9	11				1
Days 13		12	48	49				2
Hours 23			56	40				0
Minutes 8				20				0
The Suns Mean Motion.	0	1	15	15	3	5	25	11
Apogeum Subtract.	3	5	25	11				
The Anomaly of ☉	8	25	50	04				
The Equat. added to the Mean Mot.		2	2	51				
Gives the Suns true place,	♈	3	18	6				
Agreeing with the Observation.	♈	3	17	40				

(3) Example, the time given the 10 of *April* 1665 at Noon; and by the former Rules we have found the Suns Mean Motion 29 *deg.* 0 *min.* 30″, his Apogeum 3 *s.* 6 *d.* 49 *m* 29″, his Anomaly 9 *s.* 22 *d.* 11 *m.* 1″. And to find a Propor. part { the Equat. answering to 22 *d.* is 1 *d.* 52 *m.* 22″ for the Equat. proceed thus { the Equator answer. to 23 *d.* is 1 *d.* 51 *m.* 29″

their difference ——— 53

Then I say, if 1 *deg.* or 60 *min.* give 53″, what shall 11 *min.* give? By the Rule of proportion,

60 : 53 11
11

53
53

583

(4
58(3 90 18/60
6

5	0	04	55	42	0	1	5
6	6	05	54	50	0	1	6
7	0	06	53	58	0	1	7
8	0	07	53	07	0	1	8
9	0	08	52	15	0	1	9
10	0	09	51	23	0	2	10
11	0	10	50	31	0	2	11
12	0	11	49	40	0	2	12
13	0	12	48	49	0	2	13
14	0	13	47	57	0	2	14
15	0	14	47	05	0	2	15
16	0	15	46	13	0	3	16
17	0	16	45	22	0	3	17
18	0	17	44	30	0	3	18
19	0	18	43	38	0	3	19
20	0	19	42	47	0	3	20
21	0	20	41	55	0	3	21
22	0	21	41	03	0	4	22
23	0	22	40	12	0	4	23
24	0	23	39	20	0	4	24
25	0	24	38	28	0	4	25
26	0	25	37	37	0	4	26
27	0	26	36	45	0	4	27
28	0	27	35	53	0	5	28
29	0	28	35	02	0	5	29
30	0	29	34	10	0	5	30
31	0	00	33	18	0	5	M

5	0	12	19	35	1	26	
6	0	14	47	36	1	29	
7	0	17	15	37	1	31	
8	0	19	43	38	1	34	
9	0	22	11	39	1	36	
10	0	24	38	40	1	39	
11	0	27	6	41	1	41	
12	0	29	34	42	1	43	
13	0	32	2	43	1	46	
14	0	34	30	44	1	48	
15	0	36	58	45	1	51	
16	0	39	25	46	1	53	
17	0	41	53	47	1	56	
18	0	44	21	48	1	58	
19	0	46	49	49	2	01	
20	0	49	17	50	2	03	
21	0	51	45	51	2	06	
22	0	54	13	52	2	08	
23	0	56	40	53	2	11	
24	0	59	8	54	2	13	
25	1	01	36	55	2	16	
26	1	04	04	56	2	18	
27	1	06	32	57	2	20	
28	1	09	00	58	2	23	
29	1	11	27	59	2	25	
30	1	13	55	60	2	28	
	m.	*sc.*	*th.*	*sc.*	*sc.*	*th.*	

A Table of the Suns Equation.

Sig. 0 Sub.			Sig. 1 Sub			Sig. 2 Sub.			Sig. 3 Sub.			Sig. 4 Sub.			Sig. 5 Sub.		
D	M	S	D	M	S	D	M	S	D	M	S	D	M	S	D	M	S
0	0	0	0	59	32	1	44	28	2	2	54	1	48	23	1	3	26
1	0	2	5	1	1	21	1	45	34	2	2	56	1	47	20	1	1	32
2	0	4	9	1	3	10	1	46	38	2	2	56	1	46	15	0	59	37
3	0	6	12	1	4	57	1	47	41	2	2	55	1	45	9	0	57	40
4	0	8	16	1	6	42	1	48	40	2	2	52	1	44	1	0	55	42
5	0	10	19	1	8	26	1	49	38	2	2	47	1	42	50	0	53	43
6	0	12	22	1	10	9	1	50	34	2	2	39	1	41	37	0	51	43
7	0	14	25	1	11	51	1	51	29	2	2	29	1	40	22	0	49	42
8	0	16	28	1	13	32	1	52	22	2	2	17	1	39	4	0	45	39
9	0	18	30	1	15	11	1	53	13	2	2	2	1	37	45	0	45	35
10	0	20	32	1	16	49	1	54	1	2	1	46	1	36	24	0	43	31
11	0	22	34	1	18	26	1	54	43	2	1	29	1	35	3	0	41	26
12	0	24	37	1	20	02	1	55	31	2	1	7	1	33	39	0	39	20
13	0	26	39	1	21	36	1	56	14	2	0	44	1	32	2	0	37	14
14	0	28	41	1	23	9	1	56	55	2	0	18	1	30	44	0	35	6
15	0	30	42	1	24	41	1	57	34	1	59	49	1	29	13	0	32	58
16	0	32	43	1	26	11	1	58	10	1	59	19	1	27	41	0	30	50
17	0	34	44	1	27	40	1	58	44	1	58	47	1	26	7	0	28	41
18	0	36	43	1	29	8	1	59	16	1	58	12	1	24	32	0	26	31
19	0	38	41	1	30	34	1	59	46	1	57	35	1	22	56	0	24	21
20	0	40	38	1	31	58	2	0	14	1	56	56	1	21	18	0	22	10
21	0	42	35	1	33	20	2	0	40	1	56	14	1	19	38	0	19	59
22	0	44	31	1	34	41	2	1	04	1	55	30	1	17	56	0	17	48
23	0	46	27	1	36	0	2	1	26	1	54	44	1	16	12	0	15	36
24	0	48	22	1	37	17	2	1	46	1	53	56	1	14	26	0	13	33
25	0	50	16	1	38	33	2	2	3	1	53	5	1	12	40	0	11	10
26	0	52	09	1	39	48	2	2	18	1	52	12	1	10	52	0	8	57
27	0	54	1	1	41	1	2	2	30	1	51	18	1	9	2	0	6	43
28	0	55	52	1	42	12	2	2	40	1	50	21	1	7	11	0	4	29
29	0	57	42	1	43	21	2	2	48	1	49	23	1	5	18	0	2	15
30	0	59	42	1	44	28	2	2	54	1	48	23	1	3	36	0	0	0
Add Sig. 11			Add Sig. 10			Add Sig. 9			Add Sig. 8			Add Sig. 7			Add Sig. 6		

Place this Table between Pag. 88 and 89.

A Table *of the* Sun's Declination.

MARCH. XXXI.

Day Mo.	Da. Week	D Epact.	Hour.	☉ Rising. and Sett.	Leap ye. 1664 1668 1672 1676 1680 1684 1688 1692 Deg.	Min.	Differ.	First. 1665 1669 1673 1677 1681 1685 1689 1693 Deg.	Min.	Differ.	Second. 1666 1670 1674 1678 1682 1686 1690 1694 Deg.	Min.	Differ.	Third. 1667 1671 1675 1679 1683 1687 1691 1695 Degr.	Min.	Differ.
1	D	29	1	David.	3	15		3	20		3	26		3	32	
2	E	26	14	5 44 7	2	51	24	2	57	23	3	3	23	3	9	23
3	F	*		5 46 7	2	28	23	2	33	24	2	29	24	2	45	24
4	G	25	10	5 48 7	2	4	24	2	9	24	2	16	13	2	21	24
5	A	24		5 50 7	1	40	24	1	46	23	1	52	24	1	58	23
6	B	23	0	5 52 7	1	16	24	1	22	24	1	28	24	1	34	24
7	C	21	11	5 54 7	0	53	23	0	59	23	1	5	23	1	11	23
8	D	21		5 56 7	0	29	24	0	35	24	0	41	24	0	46	24
9	E	20	7	5 58 7	0	5	24	0	11	24	0	17	24	0	23	23
10	F	18	20	☉ in ♈.	Nor.	18	24	Nor.	13	24	North	6	11	North	1	22
11	G	*		6 2 6	0	42	24	0	37	23	0	30	24	0	25	24
12	A	17	16	6 4 6	1	6	23	0	00	24	0	54	24	0	49	24
13	B	16		6 6 6	1	29	24	1	24	23	1	18	24	1	12	23
14	C	15	5	6 8 6	1	53	23	1	47	24	1	42	24	1	36	24
15	D	14	1	6 10 6	2	16	24	2	11	24	2	5	23	2	00	23
16	E	12	14	6 12 6	2	40	24	2	35	23	2	29	24	2	23	23
17	F	*		6 14 6	3	4	23	2	58	23	2	52	23	2	46	23
18	G	11	2	6 16 6	3	27	23	3	21	24	3	15	23	3	10	24
19	A	10		6 18 6	3	50	24	3	45	23	3	39	24	3	33	23
20	B	9	0	☉ 10 ♈.	4	14	23	4	8	23	4	2	23	3	56	23
21	C	7	11	6 22 6	4	37	23	4	31	23	4	25	23	4	19	23
22	D	*		6 24 6	5	00	23	4	54	23	4	49	24	4	43	24
23	E	6	7	5 26 6	5	23	23	5	17	23	5	12	23	5	6	23
24	F	4	20	6 28 6	5	46	23	5	40	23	5	35	23	5	29	23
25	G	*		An. Mar.	6	9	23	6	3	23	5	57	22	5	52	23
26	A	3	8	6 32 6	6	31	22	6	25	22	6	20	23	6	15	23
27	B	2		6 34 6	6	54	23	6	48	23	6	42	22	6	37	22
28	C	1	7	5 36 6	7	16	22	7	11	22	7	5	23	7	0	23
29	D	29	17	6 38 6	7	38	22	7	33	22	7	28	23	7	22	22
30	E	28	14	☉ 20 ♈.	8	1	23	7	55	22	7	50	22	7	45	23
31	F	27		6 42 6	8	23	22	8	17	22	8	12	22	8	7	22

South Declination. North Declination. South Declination. Æquinoctial North Declination.

A Table *of the* Sun's Declination.

APRIL XXX.

Day Mo.	Da. Wee.	D Epact.	Hour.	☉ Rif. and Setting.	Leap ye. 1664 1668 1672 1676 1680 1684 1688 1692 Deg.	Min.	Diff.	First. 1665 1669 1673 1677 1681 1685 1689 1693 Deg.	Min.	Differ.	Second. 1666 1670 1674 1678 1682 1686 1690 1694 Deg.	Min.	Differ.	Third. 1667 1671 1675 1679 1683 1687 1691 1695 Deg.	Min.	Differ.
1	G	26	2	6 44 6	8	45		8	39		8	34		8	29	
2	A	25	22	6 46 6	9	07	22	9	01	22	8	56	22	8	51	22
3	B	24	0	6 48 6	9	29	22	9	23	22	9	18	22	9	13	22
4	C	23	11	6 50 6	9	50	21	9	44	21	9	39	21	9	34	21
5	D	*		6 52 6	10	11	21	10	06	22	10	01	22	9	56	22
6	E	22	0	6 54 6	10	32	21	10	27	21	10	22	21	10	17	21
7	F	20	20	6 56 6	10	53	21	10	48	21	10	43	21	10	38	21
8	G	19		6 57 6	11	14	21	11	09	21	11	04	21	10	59	21
9	A	18	9	6 59 6	11	35	21	11	30	20	11	25	21	11	20	21
10	B	*		☉ *in* ♉	11	55	20	11	50	20	11	46	21	11	40	20
11	C	17	5	7 2 5	12	15	20	12	10	20	12	06	20	12	01	21
12	D	15	6	7 4 5	12	35	20	12	30	20	12	26	20	12	21	20
13	E	14	14	7 6 5	12	55	20	12	50	20	12	46	20	12	41	20
14	F	13		7 8 5	13	15	20	13	10	19	13	06	20	13	01	20
15	G	12	2	7 10 5	13	34	19	13	29	19	13	25	19	13	20	19
16	A	11	15	7 11 5	13	53	19	13	48	19	13	44	19	13	40	20
17	B	10		7 13 5	14	12	19	14	07	19	14	03	19	13	59	19
18	C	9	11	7 15 5	14	31	19	14	26	19	14	22	19	14	18	19
19	D	8		7 17 5	14	50	19	14	45	18	14	41	19	14	36	18
20	E	7	0	☉ 10 ♉	15	08	18	15	03	18	14	59	18	14	55	19
21	F	6	20	7 29 5	15	26	18	15	21	18	15	17	18	15	13	18
22	G	5		7 22 5	15	44	17	15	39	17	15	35	18	15	31	18
23	A	4	9	George.	16	01	17	15	56	18	15	53	18	15	48	17
24	B	3	21	7 25 5	16	18	17	16	14	17	16	10	17	16	06	18
25	C	2		Mark.	16	35	17	16	31	16	16	27	17	16	23	17
26	D	1	18	7 49 5	16	52	17	16	47	18	16	44	17	16	40	17
27	E	*		7 31 5	17	59	16	17	05	16	17	01	17	16	57	17
28	F	29	6	7 32 5	17	25	16	17	21	16	17	17	16	17	13	16
29	G	28	2	7 34 5	17	41	15	17	37	16	17	33	16	17	29	16
30	A	27		☉ 20 ♉	17	56	15	17	52	15	17	49	16	17	44	15

North Declination. *North Declination.*

A Table

A Table *of the* Sun's Declination.

MAY. XXXI.

Day Mo.	Da. Week	☽ Epact.	Hour.	☉ Rising and Sett.	Leap ye. 1664 1668 1672 1676 1680 1684 1688 1692 Deg.	Min.	Differ.	First. 1665 1669 1673 1677 1681 1685 1689 1693 Deg.	Min.	Differ.	Second. 1666 1670 1674 1678 1682 1686 1690 1694 Deg.	Min.	Differ.	Third. 1667 1671 1675 1679 1683 1687 1691 1695 Degr.	Min.	Differ.
1	B	*		Ph. & Ja.	18	11		18	8		18	4		18	00	
2	C	25	11	7 39 5	18	26	15	18	23	15	18	19	15	18	15	15
3	D	24		7 40 5	18	41	15	18	37	14	18	34	15	18	30	15
4	E	23		7 42 5	18	55	14	18	52	15	18	48	14	18	45	15
5	F	22	13	7 44 5	19	9	14	19	6	14	19	2	14	18	59	14
6	G	21		7 45 5	19	25	14	19	19	13	19	61	14	19	13	14
7	A	20	9	7 46 5	19	36	14	19	33	14	19	30	14	19	27	14
8	B	18	21	7 47 5	19	49	13	19	46	13	19	43	13	19	40	13
9	C	*		7 49 5	20	2	13	19	59	13	19	56	12	19	53	13
10	D	17	18	☉ in ♊.	20	14	12	20	11	12	20	8	12	20	5	12
11	E	16		7 50 5	20	26	12	20	24	13	20	20	12	20	18	13
12	F	15	6	7 53 5	20	38	12	20	36	12	20	32	12	20	30	12
13	G	14	2	7 54 5	20	49	11	20	47	11	20	43	12	20	41	11
14	A	12	15	7 55 5	21	00	11	20	57	12	20	55	11	20	52	11
15	B	*		7 56 5	21	11	10	21	9	10	21	6	10	21	3	11
16	C	11	4	7 57 5	21	21	10	21	19	10	21	16	10	21	14	11
17	D	10		7 58 5	21	31	9	21	29	9	21	26	10	21	24	10
18	E	9	0	7 59 5	21	40	10	21	38	9	21	36	9	21	34	10
19	F	7	13	8 0 4	21	50	9	21	47	9	21	45	9	21	43	9
20	G	*		8 1 4	21	59	8	21	56	9	21	54	8	21	52	9
21	A	6	9	☉ 10 ♊.	22	7	8	22	5	8	22	2	9	22	1	9
22	B	4	1	8 3 4	22	15	7	22	13	8	22	11	9	22	9	8
23	C	*		8 4 4	22	22	7	22	21	7	22	19	7	22	7	8
24	D	3	10	8 5 4	22	29	7	22	28	7	22	24	7	22	31	7
25	E	2		8 6 4	22	36	7	22	35	6	22	33	7	22	38	7
26	F	1	6	8 7 4	22	43	6	22	41	6	22	40	6	22	45	7
27	G	29	19	8 8 4	22	49	6	22	47	6	22	46	6	22	51	6
28	A	28	15	8 8 4	22	55	5	22	53	5	22	52	5	22	56	5
29	B	27		8 9 4	23	00	5	22	58	5	22	57	5	23	1	5
30	C	26	4	8 10 4	23	5	4	23	3	5	23	2	5	23	6	5
31	D	*		8 10 4	23	9	4	23	8	5	23	7	5			

North Declination. North Declination.

A Table *of the* Sun's Declination.

JUNE. XXX.

					Leap ye.			*First.*			*Second.*			*Third.*			
					1664			1665			1606			1667			
					1668			1669			1670			1671			
					1672			1673			1674			1675			
					1676			1677			1678			1679			
					1680			1681			1682			1683			
					1684			1685			1686			1687			
					1688			1689			1690			1691			
					1692			1693			1694			1695			
Day Mo.	*Dn. Week*	*D Epact.*	*Hour.*	☉ *Rising. and Sett.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	
1	E	25	0	☉ 20 ♊.	23	13		23	12		23	11		23	10		
2	F	23	13	8 11 4	23	17	4	23	16	4	23	15	4	23	14	4	
3	G	*		8 11 4	23	20	3	23	19	3	23	19	4	23	18	4	
4	A	22	1	8 12 4	23	23	2	23	22	3	23	22	3	23	21	3	
5	B	20	21	8 12 4	23	25	2	23	25	3	23	24	2	23	24	3	
6	C	19		8 12 4	23	27	2	23	27	2	23	26	2	23	26	2	
7	D	18	10	8 13 4	23	29	1	23	28	1	23	28	2	23	28	2	
8	E	*		8 13 4	23	30	1	23	29	1	23	29	1	23	29	1	
9	F	17	6	*Days at a*	23	31	0	23	30	1	23	30	1	23	30	1	
10	G	15	19	*ſtand.*	23	31	0	23	31	1	23	31	1	23	31	1	
11	A	14	15	☉ in ♋.	23	31	1	23	31	0	23	31	0	23	31	1	
12	B	13		*Days*	23	30	1	23	31	0	23	31	0	23	31	0	
13	C	12	4	*ſhorten.*	23	29	0	23	30	0	23	30	1	23	30	1	
14	D	11	16	8 13 4	23	29	2	23	29	1	23	29	1	23	29	1	
15	E	10		8 13 4	23	27	2	23	27	2	23	28	1	23	28	1	
16	F	9	13	8 12 4	23	25	3	23	25	2	23	26	2	23	26	2	
17	G	8		8 12 4	23	22	3	23	23	2	23	23	3	23	24	2	
18	A	7	1	8 12 4	23	19	3	23	20	3	23	20	3	23	21	3	
19	B	6	21	8 11 4	23	16	4	23	17	4	23	17	3	23	19	2	
20	C	5		8 11 4	23	12	4	23	13	4	23	13	4	23	15	4	
21	D	4	10	8 11 4	23	8	5	23	9	5	23	9	4	23	11	4	
22	E	*		☉ 10 ♋.	23	3	5	23	4	4	23	5	4	23	6	5	
23	F	3	0	8 10 4	22	58	5	23	0	5	23	1	4	23	2	4	
24	G	1	19	John Bapt.	22	53	6	22	55	6	22	56	5	22	57	5	
25	A	*		8 8 4	22	47	6	22	49	4	22	51	5	22	51	6	
26	B	29	6	8 8 4	22	41	7	22	43	7	22	45	6	22	45	6	
27	C	28	4	8 7 4	22	34	7	22	36	7	22	38	7	22	39	6	
28	D	26	17	8 6 4	22	27	7	22	24	7	22	31	7	22	33	6	
29	E	*		Peter Ap.	22	20	7	22	22	8	22	34	7	22	26	7	
30	F	25	13	8 4 4	22	12	8	22	14	8	22	16	8	22	18	8	

North Declination. *North Declination.*

A Table

A Table *of the* Sun's Declination.

JULY XXXI.

Day Mo.	Da. Wee.	D Epact.	Hour.	☉ Ris. and Setting.	Leap ye. 1664 1668 1672 1676 1680 1684 1688 1692 Deg.	Min.	Diff.	First. 1665 1669 1673 3677 1681 1685 1689 1693 Deg.	Min.	Differ.	Second. 1066 1670 1674 1678 1682 1686 1690 1694 Deg.	Min.	Differ.	Third. 1667 1671 1675 1679 1683 1687 1691 1695 Deg.	Min.	Differ.
1	G	24		8 3 4	22	4		22	6		22	8		22	10	
2	A	23	1	☉ 20 ♋.	21	56	8	21	58	8	22	00	8	22	2	8
3	B	22	14	8 2 4	21	47	9	21	49	9	21	51	9	21	54	9
4	C	21		8 1 4	21	38	9	21	40	9	21	42	9	21	45	9
5	D	20	10	8 0 4	21	28	10	21	31	10	21	33	9	21	35	10
6	E	19		7 58 5	21	18	10	21	21	10	21	23	10	21	26	9
7	F	18	0	7 57 5	21	8	10	21	11	11	21	13	10	21	16	10
8	G	17	19	7 56 5	20	57	11	21	00	11	21	3	10	21	5	11
9	A	16		7 55 5	20	46	11	20	49	12	20	52	11	20	54	11
10	B	15	8	7 54 5	20	34	12	20	37	11	20	40	12	20	43	11
11	C	14	4	7 53 5	20	23	11	20	26	12	20	29	11	20	31	12
12	D	12	17	7 52 5	20	11	12	20	14	12	20	17	12	20	20	11
13	E	*		☉ in ♌.	19	59	12	20	2	13	20	5	12	20	8	12
14	F	11	5	7 49 5	19	46	13	19	49	13	19	52	13	19	55	13
15	G	10		Swithin.	19	33	13	19	36	13	19	39	13	19	42	13
16	A	9	1	7 46 5	19	20	13	19	23	13	19	26	13	19	24	13
17	B	7	14	7 45 5	19	6	14	19	10	14	19	13	13	19	16	13
18	C	*		7 43 5	18	52	14	18	56	14	18	59	14	19	2	14
19	D	6	10	*Dog.d. beg.*	18	30	14	18	42	15	18	45	14	18	48	14
20	E	5		7 40 5	18	23	15	18	27	15	18	30	15	18	34	14
21	F	4		7 39 5	18	8	15	18	12	15	18	15	15	18	19	15
22	G	3	11	Magdalen.	17	53	15	17	57	16	18	00	15	18	4	15
23	A	2		☉ 10 ♌.	17	37	16	17	41	16	17	45	15	17	49	15
24	B	1	8	7 34 4	17	21	16	17	25	16	17	29	16	17	23	16
25	C	29	20	S: Jam. Ap	17	5	16	17	9	16	17	13	16	17	17	16
26	D	28	14	7 0 5	16	49	16	16	53	16	16	57	16	17	1	16
27	E	27		7 29 5	16	33	16	16	37	17	16	41	16	16	45	16
28	F	26	5	7 27 5	16	16	17	16	20	17	16	24	17	16	28	17
29	G	*		7 25 5	15	59	17	16	3	18	16	7	17	16	11	17
30	A	25	1	7 24 5	15	41	18	15	45	18	15	50	17	15	54	17
31	B	23	14	7 22 5	15	23	18	15	27	18	15	32	18	15	36	18

North Declination.

North Declination.

A Table

A Table *of the* Sun's Declination.

AUGUST XXXI.

Day Mo.	Da. Wee.	☽ Epact.	Hour.	☉ Ris. and Setting.	Leap ye. 1664 1668 1672 1676 1680 1684 1688 1692 Deg.	Min.	Diff.	First. 1665 1669 1673 3677 1681 1685 1689 1693 Deg.	Min.	Differ.	Second. 1666 1670 1674 1678 1682 1686 1690 1694 Deg.	Min.	Differ.	Third. 1667 1671 1675 1679 1683 1687 1691 1695 Deg.	Min.	Differ.	North Declination.
1	C	*		Lammas.	15	5		15	10		15	14		15	19		
2	D	22	3	7 19 5	14	47	18	14	52	18	14	56	18	15	1	18	
3	E	21	0	☉ 20 ♌	14	29	18	14	34	18	14	38	18	14	42	19	
4	F	20	0	7 16 7	14	10	19	14	15	19	14	19	19	14	24	18	
5	G	18	12	7 14 7	13	51	19	13	56	19	14	00	19	14	5	19	
6	A	*		7 12 7	13	32	19	13	37	19	13	41	19	13	46	19	
7	B	17	8	7 10 7	13	13	19	13	18	19	13	52	19	13	27	19	
8	C	15	20	7 8 7	12	54	19	12	59	19	13	3	19	13	08	19	
9	D	14	17	7 7 7	12	34	20	12	39	20	12	43	20	12	48	20	
10	E	13		Laurence.	12	14	20	12	19	20	12	23	20	12	28	20	
11	F	12	5	7 3 5	11	54	20	11	59	20	12	3	20	12	8	20	
12	G	11	18	7 1 5	11	33	21	11	38	21	11	43	20	11	48	20	
13	A	10		☉ *in* ♍	11	13	20	11	18	21	11	23	20	11	28	20	
14	B	9	14	6 58 6	10	52	21	10	57	21	11	3	20	11	7	21	
15	C	8		6 56 6	10	32	20	10	36	21	11	42	21	10	47	20	
16	D	7	3	6 54 6	10	11	21	10	15	21	10	21	21	10	26	21	
17	E	*		6 52 6	9	50	21	9	54	21	10	00	21	10	5	21	
18	F	6	0	6 50 6	9	28	22	9	33	21	9	38	22	9	44	21	
19	G	4	12	6 48 6	9	6	22	9	12	22	9	17	21	9	22	22	
20	A	*		6 46 6	8	44	21	8	50	21	9	55	22	9	1	21	
21	B	3	0	6 44 6	8	23	22	8	29	22	8	33	22	8	39	22	
22	C	1	12	6 42 6	8	1	22	8	7	22	8	12	21	8	17	22	
23	D	*		☉ 10 ♍	7	39	22	7	45	22	7	50	22	7	53	22	
24	E	29	9	Barthol.	7	17	22	7	23	23	7	28	22	7	33	22	
25	F	28	5	6 36 6	6	56	23	7	00	23	7	5	23	7	11	22	
26	G	26	18	6 34 6	6	32	22	6	38	22	6	43	22	6	45	23	
27	A	*		6 32 6	6	10	23	6	15	23	6	21	22	6	26	22	
28	B	25	14	*Dog. d end*	5	47	22	5	53	22	6	58	23	6	4	22	
29	C	24	6	6 29 6	5	25	23	5	30	23	5	35	23	5	41	23	
30	D	23	3	6 27 6	5	2		5	8	22	5	13	22	5	18	23	
31	E	22	15	6 25 6	4	39	27	4	44	24	4	52	23	4	55	23	

North Declination.

A Table *of the* Sun's Declination.

SEPTEMBER. XXX.

Day Mo.	Da. Week	☽ Epact.	Hour.	☉ Rising. and Sett.	Leap ye. 1664 1668 1672 1676 1680 1684 1688 1692 Deg.	Min.	Differ.	First. 1665 1669 1673 1677 1681 1685 1689 1693 Deg.	Min.	Differ.	Second. 1666 1670 1674 1678 1682 1686 1690 1694 Deg.	Min.	Differ.	Third. 1667 1671 1675 1679 1683 1687 1691 1695 Degr.	Min.	Differ.	
1	F	21		Giles.	4	16		4	22		4	27		4	32		
2	G	20	12	5 21 6	3	53	23	3	59	23	4	4	23	4	9	23	
3	A	19		☉ 20 ♍	3	30	23	3	35	24	3	41	23	3	46	23	
4	B	18	0	6 17 6	3	7	23	3	12	23	3	17	24	3	23	23	
5	C	17	20	6 15 6	2	43	24	2	49	23	2	54	23	3	0	23	North Declination.
6	D	16		5 13 6	2	20	23	2	26	23	2	31	23	2	37	23	
7	E	15	9	6 12 6	1	57	23	2	3	23	2	8	23	2	13	24	
8	F	14	6	Lady Fair.	1	33	24	1	39	24	1	45	23	1	50	23	
9	G	12	18	6 7 6	1	10	23	1	16	23	1	21	24	1	27	23	
10	A	*		6 5 6	0	46	24	0	52	24	0	58	23	1	3	24	
11	B	11	7	6 3 6	0	23	23	0	29	23	0	30	24	0	40	24	
12	C	10		6 1 6	0	1	22	0	5	24	0	10	24	0	16	24	
13	D	9	3	☉ in ♎	South	24	23	South	18	24	South	13	7	South	7	9	Æquinoctial
14	E	7	16	5 57 7	0	48	24	0	42	23	0	36	23	0	31	24	
15	F	*		5 55 7	1	11	23	1	5	24	1	00	26	0	54	23	
16	G	6	12	5 53 7	1	35	24	1	29	24	1	23	23	1	18	24	
17	A	5		5 51 7	1	58	23	1	52	23	1	47	24	1	41	23	
18	B	4		5 49 7	2	22	24	2	16	24	2	10	23	2	5	24	South Declination.
19	C	3		5 47 7	2	45	23	2	40	24	2	34	24	2	28	23	
20	D	1		5 45 7	3	9	24	3	3	23	2	57	23	2	52	24	
21	E	1	9	Matth. Ap	3	32	23	3	27	24	3	21	24	3	15	23	
22	F	29	22	5 42 7	3	56	24	3	50	23	3	44	23	3	38	23	
23	G	28	18	☉ 10 ♎	4	19	23	4	13	23	4	7	23	4	2	24	
24	A	27		5 38 7	4	42	24	4	36	23	4	30	23	4	25	23	
25	B	26	17	5 36 7	5	6	23	4	59	23	4	54	24	4	48	23	
26	C	*		5 34 7	5	29	23	5	23	24	5	17	23	5	12	24	
27	D	25	3	5 32 7	5	52	23	5	36	23	5	41	24	5	35	23	
28	E	23	16	5 30 7	9	15	23	6	09	23	6	4	23	5	58	23	
29	F	*		Michael.	9	38	23	6	32	23	6	16	22	6	21	23	
30	G	22	4	5 26 7	7	1	23	6	55		6	49	23	6	44	23	

North Declination. | South Declination.

A Table

A Table *of the* Sun's Declination.

OCTOBER XXXI.

Day Mo.	Da. Wee.	D Epact.	Hour.	☉ Ris. and Setting.	Leap yc. 1664 1668 1672 1676 1680 1684 1688 1692 Deg.	Min.	Diff.	First. 1665 1669 1673 3677 1681 1685 1689 1693 Deg.	Min.	Differ.	Second. 1066 1670 1674 1678 1682 1686 1690 1694 Deg.	Min.	Differ.	Third. 1667 1671 1675 1679 1683 1687 1691 1695 Deg.	Min.	Differ.
1	A	21		5 24 7	7	24		7	17		7	12		7	06	
2	B	20	0	5 22 7	7	46	22	7	40	23	7	35	22	7	29	23
3	C	18	13	☉ 20 ♏	8	9	23	8	2	22	7	58	23	7	52	23
4	D	✱		5 18 7	8	31	22	8	25	23	8	20	22	8	15	23
5	E	17	9	5 16 7	8	53	22	8	47	22	8	42	22	8	37	22
6	F	22	22	5 14 7	9	15	22	9	9	22	9	4	22	8	59	22
7	G	14	18	5 12 7	9	37	22	9	32	23	9	27	23	9	21	22
8	A	13		5 10 7	9	59	22	9	54	22	9	49	22	9	43	22
9	B	12	7	5 8 7	10	21	22	10	16	22	10	10	21	10	5	22
10	C	11	19	5 6 7	10	43	22	10	37	21	10	32	22	10	27	22
11	D	10		5 4 7	11	04	21	10	59	22	10	53	21	10	48	21
12	E	9	16	5 2 7	11	25	21	11	20	21	11	15	22	11	10	22
13	F	8		☉ *in* ♏	11	46	21	11	41	21	11	36	21	11	31	21
14	G	7	4	4 59 8	12	7	21	12	2	21	11	57	21	11	52	21
15	A	✱		4 57 8	12	28	21	12	23	21	12	18	21	12	13	21
16	B	6	0	4 55 8	12	48	20	12	44	21	12	39	21	12	34	21
17	C	4	13	4 53 8	13	9	21	13	4	20	12	59	20	12	54	20
18	D	✱		Luke.	13	29	20	13	24	20	13	20	21	13	14	20
19	E	3	1	4 49 8	13	49	20	13	44	20	13	40	20	13	34	20
20	F	2		*Tref. Mic.*	14	9	20	14	4	20	13	59	19	13	54	20
21	G	1	0	*Except.*	14	28	19	14	24	20	14	19	20	14	14	20
22	A	29	11	*Ret. Brev.*	14	48	20	14	43	19	14	38	19	14	34	20
23	B	28	7	*Termbegin*	15	7	19	15	2	19	14	57	19	14	53	19
24	C	26	19	4 40 8	15	26	19	15	21	19	15	16	19	15	12	19
25	D	✱		Crispin.	15	44	18	15	40	19	15	35	19	15	31	19
26	E	25	16	☉ 13 ♏	16	2	18	15	58	18	15	53	18	15	49	18
27	F	24		*Mens. Mi.*	16	20	18	16	16	18	16	11	18	16	7	18
28	G	23	4	Sim. Jude	16	38	17	16	33	17	16	29	18	16	25	18
29	A	22	17	*Ret Brev.*	16	55	17	16	51	18	16	45	18	16	32	17
30	B	21		*Appear.*	17	12	17	17	8	17	17	4	17	17	00	18
31	C	20	13	4 2 8	17	29	17	17	25	17	17	21	17	17	17	17

South Declination. *South Declination.*

A Table

A Table *of the* Sun's Declination.

NOVEMBER. XXX.

					Leap ye.			*First.*			*Second.*			*Third.*			
					1664			1665			1606			1667			
					1668			1669			1670			1671			
					1672			1673			1674			1675			
					1676			1677			1678			1679			
					1680			1681			1682			1683			
					1684			1685			1686			1687			
					1688			1689			1690			1691			
					1692			1693			1694			1695			
Day Mo.	*Da. Week*	*D Epact.*	*Hour.*	☉ *Rising. and Sett.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Deg.*	*Min.*	*Differ.*	*Degr.*	*Min.*	*Differ.*	
1	D	19		All Saints.	17	46		17	41		17	38		17	32		
2	E	18	2	All Souls.	18	2	16	17	58	17	17	54	16	17	50	17	
3	F	*		*Craſt. An-*	18	18	16	18	14	16	18	10	16	18	6	16	
4	G	17	0	*Except.*	18	33	15	18	30	16	18	26	16	18	22	16	
5	A	15	11	PowderTr.	18	48	15	18	45	15	18	41	15	18	37	15	
6	B	14	7	*Appear.*	19	3	15	19	00	15	18	56	15	18	53	16	
7	C	12	19	4 16 8	19	18	15	19	14	15	19	11	15	19	8	15	
8	D	*		☉ 25 m.	19	32	14	19	29	14	19	25	14	19	22	14	
9	E	11	8	4 15 8	19	46	14	19	43	14	19	39	14	19	36	14	
10	F	8		4 13 8	19	59	13	19	56	13	19	53	14	19	50	14	
11	G	9	4	Martin.	20	13	14	20	10	14	20	06	13	20	3	13	
12	A	7	17	*Craſt. Ma.*	20	26	13	20	23	13	20	19	13	20	16	13	
13	B	*		*Except.*	20	38	12	20	35	12	20	31	12	20	29	13	
14	C	6	13	*Ret. Brev.*	20	50	12	20	47	12	20	43	12	20	41	12	
15	D	5		*Appear.*	20	2	10	20	59	12	20	55	12	20	53	12	
16	E	4	2	☉ 4 ♐	21	13	11	21	10	11	21	7	12	21	5	12	
17	F	3	14	4 3 8	21	23	10	21	21	11	21	18	11	21	16	11	
18	G	2		*Oct. Mar.*	21	34	11	21	31	10	21	29	11	21	26	10	
19	A	1	11	*Except.*	21	44	10	21	41	10	21	39	10	21	35	10	
20	B	29	23	*Ret. Brev.*	21	54	10	21	51	10	21	49	10	21	46	10	
21	C	28	20	*Appear.*	22	3	9	22	00	9	21	58	9	21	56	10	
22	D	27		☉ 10 ♐	22	11	8	22	09	9	21	7	9	22	5	9	
23	E	26	8	3 56 9	22	20	9	22	18	9	22	16	9	22	13	8	
24	F	*		3 55 9	22	28	8	22	26	8	22	24	8	22	22	9	
25	G	25	4	*Qu. Mar.*	22	35	7	22	34	8	22	31	7	22	30	8	
26	A	23	17	*Except.*	22	42	7	22	41	7	22	39	8	22	37	7	
27	B	*		*Ret. Brev.*	22	48	6	22	48	7	22	45	6	22	44	7	
28	C	22	6	*Term endt.*	22	54	6	22	54	6	22	52	7	22	50	6	
29	D	21		3 51 9	23	00	6	22	59	5	22	58	6	22	56	6	
30	E	20	2	Andrew.	23	05	5	23	4	5	23	3	5	23	2	6	

South Declination. *South Declination.*

A Table of the Sun's Declination.

DECEMBER XXXI.

					Leap ye.		First.		Second.		Third.		
					1664		1665		1666		1667		
					1668		1669		1670		1671		
					1672		1673		1674		1675		
					1676		1677		1678		1679		
					1680		1681		1682		1683		
					1684		1685		1686		1687		
					1688		1689		1690		1691		
					1692		1693		1694		1695		
Day Mo.	Da. Wee.	☽ Ep agz.	Hour.	☉ Ris. and Setting.	Deg.	Min.	Dec.	Min.	Diff.	Dec.	Min.	Diff.	Dec.	Min.	Diff.	Dec.	Min.	Diff.	
1	F	18	15	☉ 20 ♑	23	10		23	9		23	08		23	06				
2	G	✱		3 50 9	23	14	6	23	13	4	23	12	4	23	11	5			
3	A	17	11	3 49 9	23	18	4	23	17	4	23	16	4	23	15	4			
4	B	15	28	3 48 9	23	21	3	23	20	3	23	20	4	23	19	4			
5	C	14	29	3 48 9	23	24	3	23	23	3	23	23	3	23	22	3			
6	D	13		3 48 9	23	26	2	23	26	3	23	25	3	23	25	3			
7	E	12	8	3 47 9	23	28	2	23	28	2	23	27	2	23	27	2			
8	F	11	21	*Days are*	23	30	2	23	29	1	23	29	2	23	28	1			
9	G	10		*at a ſtand.*	23	31	1	23	30	1	23	30	1	23	30	2			
10	A	9	17		23	31	0	23	31	1	23	31	1	23	31	1			
11	B	8		☉ in ♓.	23	31	0	23	31	0	23	31	0	23	31	0			
12	C	7	6	*Days in-*	23	30	1	23	31	0	23	31	0	23	31	0			
13	D	✱		*creaſe.*	23	29	1	23	30	1	23	30	1	23	30	1			
14	E	6	2	3 47 9	23	28	1	23	29	2	23	29	1	23	29	1			
15	F	4	15	3 47 9	23	26	2	23	27	2	23	27	2	23	27	2			
16	G	✱		3 48 9	23	24	2	23	25	2	23	25	2	23	25	2			
17	A	3	5	3 48 9	23	21	3	23	22	3	23	22	3	23	23	2			
18	B	2		3 49 9	23	18	3	23	19	3	23	19	3	23	20	3			
19	C	1	0	3 49 9	23	14	4	23	15	4	23	16	4	23	16	4			
20	D	29	12	☉ 9 ♈	23	9	5	23	10	5	23	12	4	23	12	4			
21	E	28	8	Thomas.	23	5	4	23	6	6	23	7	5	23	8	5			
22	F	27		3 50 9	23	00	5	23	1	6	23	2	5	23	3	5			
23	G	26		3 51 9	22	54	6	22	55	6	23	57	5	22	54	5			
24	A	25	17	3 52 9	22	48	6	22	49	7	23	51	6	22	52	6			
25	B	24		Chriſtmas.	22	41	7	22	43	8	22	45	6	22	46	6			
26	C	23	6	Stephens.	22	34	7	22	36	8	22	38	7	22	39	7			
27	D	22	18	John.	22	27	7	22	21	8	22	31	7	22	32	7			
28	E	21		Innocents.	22	19	8	22	20	8	22	23	8	22	25	7			
29	F	20	15	3 56 9	22	11	8	22	12	8	22	15	8	22	17	8			
30	G	19		3 57 9	22	9	8	22	4	9	22	6	9	22	8	9			
31	A	18	3	3 58 9	21	58	6	21	55	9	21	57	9	21	59	9			

South Declination. South Declination.

To

To find the Sun's Declination *upon every day of the Year.*

THE *Sun's Year* (that is, the time that the *Sun* goeth out of a certain *Point* of the *Ecliptick*, and returneth again to the ſame) is not of 365 *days* juſt; but about 5 *Hours* and 49 *Minutes* more (that is, little leſs than 6 *Hours*;) Wherefore after three Years, there is always added to the fourth four times 6 *Hours*, that is, a *Day* more in *February*, for to count the *Year* or the *Revolution* of the *Sun* in even *Days*; therefore that *fourth* Year is called *Leap-year*: wherefore when we deſcribe the *Sun's Declination* in *Tables*, we always uſe to make four ſeveral *Tables*, for four ſuch Years following one the other; and yet by reaſon of the aforeſaid difference, that four *Revolutions* of the *Sun* do not juſtly make up one *Day*, but wants about 44 *min.* bringeth in proceſs of time ſo great a difference in the *Declination*, that it is needful every twenty Years to renew ſuch *Tables*.

How to find the *Leap-years*, it is thus: Divide the Year of our *Lord* above 1600 by 4; if the *Diviſion* doth fall out even, without any *overplus*, that Year then is a *Leap-year* of 366 Days: But if out of the *Diviſion* there remain any *Number*, that Remainder ſheweth how many *Years* that *Year* propounded is after the *Leap-year*.

For EXAMPLE.

I deſire to know what Year the Year 1666 is. Leaving 1600, I divide 66 by 4, and I find there remains 2; whereby I find the Year 1666 to be the ſecond Year after the *Leap-year*. In the like manner you muſt work for any other Years.

As for EXAMPLE.

It is required to know what Year 1692 is. Leaving the 1600, divide the 92 by 4, and nothing remains upon the *Diviſion*; wherefore I find that Year 1692 is a *Leap-year*.

For to know the ſame by the foregoing *Tables*, it is thus. Each *Month* hath 12 *Columns*; The firſt thereof ſhews the *days* of the *Month*; the ſecond *Column*, having the *Dominical Letters*, ſhews the *days* of the *Week*; the third *Column* having two Rows of Figures, the firſt of them ſhews the *Epact* of the *Moon*, and the other the *Hour* of the *Day*, reckoning the ſaid Hours always from *Noon*; the fourth *Column* ſhews the chief *Days* of the Year, and the *Terms* and their *Returns* which are fixed and certain; and in the void places it ſhews the *Riſing* and *Setting* of the *Sun* in this *Latitude*, and the Place of the *Sun* every 10*th* Day. Theſe four *Columns* of themſelves are fit for ordinary uſe, and may with a little pains perform all the *Concluſions* which the yearly *Almanacks* do, as you ſhall ſee by the following *Rules*.

The fifth *Column* of the foregoing *Tables* ſhews the *Sun's Declination* for every *day* of the *Year*, for all theſe *Years* in the firſt *Column* under-written, which are all *Leap-years*. The ſixth *Column* ſhews the *daily Difference* of the *Sun's Declination*. The ſeventh *Column* ſhews it for the firſt Year from the *Leap-year*. The eighth the *daily Difference* of the *Sun's Declination* in that Year. The ninth, ſhews the ſecond Year from the *Leap-year*; The tenth, the *Difference*; the eleventh, the third Year from the *Leap-year*; the twelfth, the *Difference*. This *Table* following ſhews the *Leap-years*, *Firſt*, *Second*, and *Third* after the *Leap-years*, as they are expreſſed in the Head of the *Table*.

Leap-years.	*First.*	*Second.*	*Third.*
1664	1665	1666	1667
1668	1669	1670	1671
1672	1673	1674	1675
1676	1677	1678	1679
1680	1681	1682	1683
1684	1685	1686	1687
1688	1689	1690	1691
1692	1693	1694	1695

The foregoing *Tables* of the *Sun's Declination* are calculated for the *Meridian* of the City of *London*. The *Conſtant Kalendar* I borrowed out of Ingenious Mr. *Philips's Purchaſer's Pattern.*

A Table *by which you may proportion the* Sun's Declination *to any other* Meridian.

The Difference in Declination *daily.*	M 00	M 03	M 06	M 09	M 12	M 15	M 18	M 21	M 24
	M	M	M	M	M	M	M	M	M
Deg. 15	0	0	0	0	0	0	1	1	1
30	0	0	0	0	1	1	1	2	2
45	0	0	0	1	1	2	2	3	3
Degres *of* 60	0	0	1	1	2	2	3	3	4
Differences of 75	0	0	1	2	2	3	4	4	5
Longitude 90	0	0	1	2	3	4	4	5	6
either East *or* 105	0	1	2	2	3	4	5	6	7
West. 120	0	1	2	3	4	5	6	7	8
135	0	1	2	3	4	5	7	8	9
150	0	1	2	3	5	6	8	9	10
165	0	1	2	4	5	6	8	10	11
180	0	1	3	4	6	7	9	11	12

Of the Difference *of the* Declination *in divers places of the* Earth.

NOte this, they that are more *Eaſterly* from the *Meridian* of *London*, have the *Declination* leſs when the *Declination* increaſeth either *Northward* or *Southward*; and when the *Sun's Declination* decreaſeth, it is greater.

On the contrary, they that are more *Weſterly* from the *Meridian* of *London*, when the *Declination* increaſeth *North* or *South*, have more *Declination*, and leſs when the *Declination* decreaſeth.

EXAMPLE I.

On the 26*th* of *March*, the firſt Year after the *Leap-year*, I deſire to know the *Declination* of the *Sun* at *Noon* at *Bantam* in the *Eaſt-Indies*. I find by *Globes* or the *Plat* of *Mercator*, that *Bantam* is to the *Eaſtward* of the *Meridian* of *London* about 110 *Degrees*; (we do not eſteem of a *degree* or two, becauſe it amounteth to nothing in this buſineſs.) Say, If one Revolution of the *Sun*, which is 360 *degrees*, requires 24 *hours*, what time will 110 *degrees*? *Facit* 7 *hours*, and ſomething more, whereby the *Sun* comes to the *Meridian* 7 *Hours* ſooner at *Bantam*, than it doth at *London*: ſo that it is 12 a Clock at *noon* at *Bantam*, when it is 4 of the Clock in the *Morning* with us at *London*. The *Sun's Declination* for the 26*th* of *March*, is 6 *deg.* 25 *min.* The *difference* of the *Declination* of the Day following you find is 23 *min.* which it is increaſing. Therefore I ſay, If in 24 *hours* the *Declination* increaſeth 23 *Minutes*, How much then in 7 *hours*? *Facit* almoſt 7 *Minutes*, that the *Declination* is leſs than it is at *London*. So that the *Declination* at *Bantam* that day is but 6 *deg.* 18 *min. North.*

360.24.110
24
440
220
(1 2640
8(2
264(0 (7
80(0
161
24. 23. 7.
7
161
(2
4(7 (6
161
24

EX-

EXAMPLE II.

By the foregoing Table.

On the 17*th* of *September* in the ſame Year, I deſire to know the *Declination* that day at *Noon* at *Bantam*. The *Declination* for the *Meridian* of *London* is that day 1 *deg.* 52 *min.* and the *Difference* of the *Declination* of the day following is 24 *min.* decreaſed; and, as was ſaid before in the laſt *Example*, the difference of *Longitude* is 110*deg.* Therefore I look in the Head of the foregoing *Table*, for the neareſt *Number* to the *difference* 24, and find it to fall on the Head of the laſt *olumn*; then look on the left hand of the *Table* for the *Difference* of *Longitude*, and I find 105 *deg.* neareſt, and in the *Common Angle* of *Meeting* I find 7, which is to be ſubtracted from the *Declination* in the *Meridian* of *London* aboveſaid, 1 *deg.* 52 *min.* and the *Remainder* will be the *Declination* for the *Meridian* or *Longitude* I am in, which is 1 *deg.* 45 *min. South.* But if the *Declination* decreaſeth, as it doth here increaſe, then you muſt have added.

	deg.	*min.*	
In the Meridian *of* London *the* Declination	01	52	
The Minutes Proportional *ſubtracted*	00	07	
The Declination *for* 110 deg. Longitude *of* Bantam, Eaſt,	01	45	
The Declination *of* 110 deg. Weſt *of the* Meridian *of* London	01	59	*Weſt.*

EXAMPLE III.

A *Ship* being come on the 7*th* of *November*, in the third year after the *Leap-year*, into the great *South-Sea*, thwart of the Coaſt of *Peru*, in *Longitude* 76 *deg.* from *London*. The *Pilot* deſireth the *Declination* there at *Noon* in that *Meridian*.

	deg.	*min.*	
In the Meridian *of* London *the* Declination *is*	19	08	*South.*
The Minutes Proportional *added*	00	03	
In the Longitude 76 *deg. the* Declination	19	11	*Weſt.*
In the Longitude *of* 76 *deg.* Eaſt, *the* Declination *is*	19	05	

A Table *of tae* Refractions *of the* Sun, Moon, *and* Stars, *according to the Obſervation of the thrice Noble* Tycho Brahe.

Altitudes	*Sun.*	*Moon*	*Stars.*	*Altitud.*	*Sun.*	*Moon*
	min.	*min.*	*min.*		*min.*	*min.*
0	34	33	30	18	06	06
1	26	25	21	19	05	06
2	20	20	15	20	04	05
3	17	17	13	21	04	05
4	15	15	11	22	03	04
5	14	14	10	23	03	04
6	13	14	09	24	03	04
7	12	13	08	25	02	03
8	11	12	07	26	02	03
9	10	11	06	27	02	03
10	10	10	05	28	02	02
11	09	10	05	29	02	02
12	09	10	04	30	01	02
13	08	09	04	31	01	02
14	08	08	03	32	01	01
15	07	08	03	33	01	01
16	07	07	02	34	01	01
17	06	07	02	35	01	01

THE *Refraction* of the *Sun*, *Moon*, and *Stars*, cauſeth them to appear higher above the *Horizon* than they are: therefore the *Refraction* is always to be ſubtracted from the *Altitude* obſerved, that the true *Altitude* may be had.

As for Example.

The *Sun's Meridian Altitude* by Obſervation being 9 *degrees*, I require the true *Altitude*.

	deg.	*mi.*
Altitude *by Obſervation*	9	00
Refraction *ſubtract*	0	10
The true Meridian Altitude.	8	50

By reaſon of the *Refraction* of the *Sun*, a *Dutch* Ship being upon the diſcovery of a *North-Eaſt* Paſſage to the *Eaſt-India*, and Winter being in *Nova Zemblia*, the Mariners beheld the *Sun* 17 days ſooner than he ſhould by his *Declination* appear above the *Horizon*, which is cauſed by the groſs *Vapours*, and thickneſs of the *Air* near the *Horizon*.

THE

The USE of the CONSTANT KALENDAR.

I. *To know the* Day *of the* Month.

THis is the Chief Uſe of an *Almanack*, and may as well be performed by this, as by any other. To this purpoſe you muſt by the general *Kalendar* at the beginning hereof, know the *Dominical* or *Sunday-Letter* for the *Year*; then conſidering with your ſelf whether it be the beginning, midſt, or end of the *Month*, (as you muſt do in any *Almanack*) find this *Letter* in the beginning, midſt, or end of the *Month*, and reckoning from it to the *Day* of the *Week*, either *Munday*, or *Tueſday*, or whatſoever other day it is, right againſt the *day* of the *Week*, you ſhall find what *day* of the *Month* it is. Here is no difficulty in this; only when it is *Leap-year* you ſee there is two *Sunday Letters*, the firſt of theſe you muſt uſe only to the 24*th* of *February*, and the other all the year after.

For Example. In 1668. the *Dominical Letters* E D the firſt *Sunday* in *January*, is at the firſt E, which is at the fifth *day* of the *Month*; the firſt *Sunday* in *February* is at the ſecond *day* of the *Month*; but the firſt *Sunday* in *March* is at the firſt D, which is at the firſt day of the *Month*, and ſo all the year after.

II. *To know what* Day *of the* Week *any* Notable Day *will fall upon in any* Year.

FIrſt, find the *Dominical Letter* in the former *Table*; then find your *Letter* in your *Month* next before the *Day* you deſire, and ſo from thence count the *Days* of the *Week*, till you come to the *Day* deſired. Thus if you would know what *Day* of the Week *Lady-day* falls upon in this Year 1668. the *Dominical Letter* is D; this is three *days* before the ſaid *day*, therefore it falls upon a *Wedneſday*.

But now in the year 1669. when the *Dominical Letter* is C, *Lady-day* will be upon the *Thurſday*.

III. *To find the Time of* Sun-riſing *and* Setting.

THis is ſet down for moſt of the *days* in the year, for *London*; and may ſerve for moſt Parts of *England*: And this is done after ſomewhat a briefer manner than is uſual, making the *Minutes* which are placed in the midſt, to ſerve both the *hours* of *Setting* and *Riſing*; which you muſt underſtand thus: The 7*th* of *February* you ſhall find theſe *Figures*, 4. 59. 8. that is, the *Sun* that Day ſets at 4 *h.* 59 *min.* that is, 59 *min.* after 4. and riſeth at 59 *m.* 8 *h.* that is, 59 *m.* before 8. or at 1 *min.* paſt 7. a Clock. And ſo you muſt account them always, remembring, That as the *Minutes* follow the firſt *Figure*, ſo they muſt be reckoned in Time after it; as they ſtand before the laſt *Figure*, ſo they muſt be reckoned in Time before it.

	ho.	*min.*
If you double this time of Sun-ſetting	04	59
You have the Length of the Day	09	58
If you ſubtract it from	12	00
You have the time of Riſing	07	01
And this doubled ſhews the Length of the Night	14	02

IV. *To find the Place of the* Sun.

THis is ſet down in the *Kalendar* about every tenth *day*; ſo that reckoning a *degree* for each day between, you ſhall have the place of the *Sun* exact enough for moſt ordinary Uſes. Thus the 10*th* of *March* the *Sun* enters into *Aries*; therefore the 15*th day*, or five *days* after, the *Sun* is in five *degrees* of *Aries*.

V.

V. *To find the* Day *and* Hour *of the* New Moon, *and thereby the* Full *and* Quarters.

FIrſt you muſt find the *Moon's Epact* for the preſent Year you are in: This *Number* is found out in the *Firſt Book, page* 9. and alſo in the *Table* at the beginning of the *Kalendar*. The *Change* alſo may be found out by the *Golden Number*: but it is much handſomer and readier to find out by this *Epact*, which runs for the moſt part in a Conſtant Order, only here and there skipping a *day*, which is marked thus, *.

Having found out the *Epact* for this preſent Year, turn to the *Month* you deſire, and there find out the ſaid *Number* of the *Epact* in the third *Column* of the *Months*, and mark what *day* of the *Month* it ſtands againſt, for that is the *day* of the *Change* or *New Moon*. Likewiſe if you have reſpect unto the *Dominical Letter*, which is by it, you ſhall ſee what *day* of the *Week* it is.

Now here in this *Column* there are two Rows of *Figures*; the firſt ſhews the *Epact-Number*, and the next the *Time* of the *Day* reckoned by the *Hours* from *Noon*, which are plain to underſtand till you come to 12 *hours* after *Noon*, which is *Midnight*; but then the *Numbers* above 12, you muſt reckon to the *Morning* of the next *day*.

So that theſe *Hours* after *Noon*,
13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24,
are all one with theſe,
1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,
at *Noon* the next *day* in the *Morning*.

Thus in the Year 1666. the *Epact* being 4, and the *Dominical Letter* G, you ſhall find this *Epact-Number* 4, in the *month* of *July*, againſt the 21*th day*, being *Saturday*; and the *Figure* 0 ſtanding by it, ſhews that the *New Moon* is juſt at *Noon*.

Again in the *month* of *November*, you ſhall find the *Epact* 4, againſt the 16*th* day being *Friday*; and the *figure* of 2 ſtanding by it, ſhews that about 2 *hours* after *Noon* the *Moon* changeth.

Having firſt found out the time of the *New Moon*, you may from thence reckon the *Age* of the *Moon*, and find the *Quarters* and *Full Moon*.

Thus the *Moon's Age* is	Days.
At the Firſt Quarter	7
At the Full Moon	15
At the Laſt Quarter	22

The End of the Second Book.

THE

THE

THE Mariners Magazine; OR, STURMYS *Mathematical* and *Practical* ARTS.

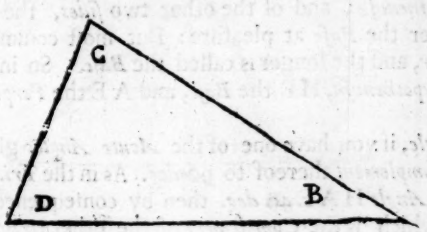
The Third Book.

CHAP. I.

Of the Affection of Right-lin'd Triangles.

THis *Third Book* is as it were a *Key* to theſe that follow, the Subject whereof is *Trigonometry*; therefore I hold it convenient before I come to the following *Practice*, to ſay ſomething concerning *Plain* and *Spherical Triangles*, although the *Subject* be handled by divers able *Mathematicians* already, whoſe Works are extant, (*viz.*) *Pitiſcus*, *Snellius*, the Lord *Napier*, *Gunter*, *Norwood*, *Gellibrand*: ſo that thoſe who deſire to make a further ſcrutiny into *Trigonometry*: may peruſe the forementioned *Authors*.

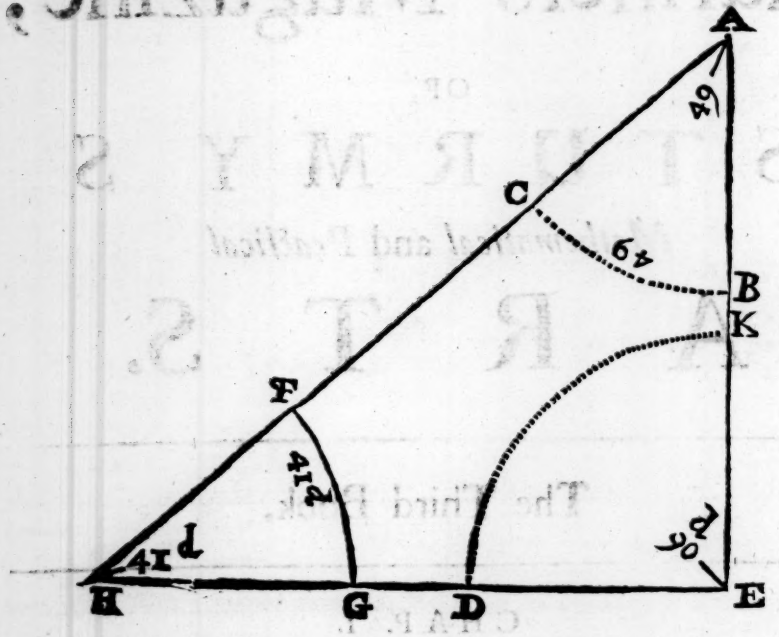
Before we come to ſhew how the Quantity of the *Sides* and *Angles* of any *Triangle* may be found by the *Tables* of *Artificial Sines*, *Tangents*, and *Logarithms*, and by the *Lines* of *Artificial Sines*, *Tangents*, and *Numbers*, take theſe following *Theorems*, as neceſſaries thereunto.



I. A *Triangle* is a *Figure* conſiſting of three *Sides*, and three *Angles*, as in the *figure* DBC.

II. Any two *Sides* of a *Triangle*, are called the *Sides* of the *Angle* comprehended by them; as the *Sides* CB and DB, are the *Sides* containing the *Angle* CBD.

III. The *Meaſure* of an *Angle* is the Quantity of an *Arch* of a *Circle*, deſcribed on the *Angular Point*, and cutting both the containing *ſides* of the ſame *Angle*: As in the *Triangle* following, the *Arch* C B is the Meaſure of the *Angle* at A, the *Arch* K D is the Meaſure of the *Angle* at E, and the *Arch* F G is the Meaſure of the *Angle* at H. Each of theſe *Arches* are deſcribed on the *Angular Points* A, H, E, and cut the containing *Sides*.



IV. A *Degree* is the 360 part of a *Circle*.

V. A *Semicircle* containeth 180 *degrees*.

VI. A *Quadrant* containeth 90 *degrees*.

VII. The *Complement* of an *Angle* leſs than a *Quadrant*, is ſo much as that *Angle* wanteth of 90 *degrees*; as if the *Angle* A H E ſhould contain 41 *degrees*, the *Complement* thereof would be 49 *deg*. For if you take 41 from 90, there will remain 49 *deg*.

VIII. The *Complement* of an *Angle* to a *Semicircle*, is the Remainder thereof to 180 *degrees*.

IX. An *Angle* is either *Right*, *Acute*, or *Obtuſe*.

X. A *Right Angle* is that whoſe Meaſure is a *Quadrant*.

XI. An *Acute Angle* is leſs than a *Right Angle*.

XII. An *Obtuſe Angle* is greater than a *Quadrant*.

XIII. A *Triangle* is either *Right-Angled*, or *Obtuſe-Angled*.

XIV. A *Right-Angled Triangle* is that which hath one *Right Angle*; as the *Triangle* A H E is *Right-Angled* at E.

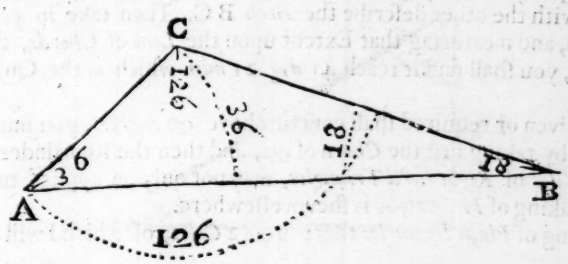
XV. In every *Right-Angled Triangle*, that *Side* which ſubtendeth (or lieth oppoſite to) the *Right Angle*, is called the *Hypothenuſa*; and of the other two *ſides*, the one is called the *Perpendicular*, and the other the *Baſe* at pleaſure: But moſt commonly the ſhorteſt is called the *Perpendicular*, and the longer is called the *Baſe*. So in the former *Triangle*, the *ſide* A H is the *Hypothenuſa*, H E the *Baſe*, and A E the *Perpendicular*.

XVI. In every *Right-Angled Triangle*, if you have one of the *Acute Angles* given, the other is alſo given, it being the *Complement* thereof to 90 *deg*. As in the *Triangle* A H E, ſuppoſe there were given the *Angle* H A E 49 *deg*. then by conſequence the *Angle* A H E muſt be 41 *degrees*, which is the *Complement* of the other to 90 *degrees*.

XVII. The three *Angles* of any *Right-lined Triangle* whatſoever, are equal to

two

two *Right Angles*, or two 180 *degrees*: ſo that if of any *Right-Lined Triangle*, you have any two of the *Angles* given, you have the third *Angle* alſo given, it being the *Complement* of the Sum of the two given *Angles* to 180 *deg.*



So in this *Triangle* A B C, if there were given the *Angle* B A C 36 *degrees*, and the *Angle* A C B 126 *degrees*, I ſay by the conſequence, there is alſo given the third *Angle*. For if you add the two given *Angles* together and ſubtract the Sum from 180 *degrees*, there will remain A B C 18 *degrees*.

In all plain *Triangles*, the *Sides* are in ſuch proportion one to the other, as the *Sines* of the *Angles* oppoſite to thoſe *Sides*. So in the *Triangle* A B C, the *Sine* of the *Angle* A C B is in ſuch proportion to the *Side* A B, as the *Sine* of the *Angle* C A B is to the *Side* B C. And ſo of any other.

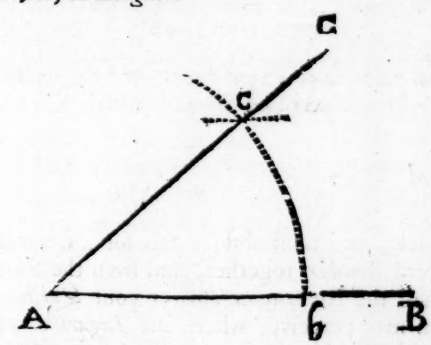
CHAP. II.

Containing the Doctrine *of* Right-lined Triangles, *both* Right-Angled *and* Oblique-Angled; *and the ſeveral* Caſes *therein reſolved, both by* Tables, *and alſo by the* Lines *of* Artificial Numbers, Sines, *and* Tangents.

I Come now to ſhew you how a *Plain Triangle* may be reſolved; that is, by having three of the ſix Parts of a *Plain Triangle*, provided one of them be a *Side*, to find a fourth.

In all the *Caſes* following I have made uſe of but two *Triangles* for *Examples*; one *Right-Angled*, the other *Oblique-Angled*: but in either of them I have expreſſed all the Varieties that are neceſſary.

The *Sides* of any *Plain Triangle* may be meaſured by any *Scale* of *Equal Parts*; as an *Inch* divided into 10 *parts*, 20 or 30 *Parts*, repreſenting *Inches*, *Feet*, *Yards*, *Poles*, *Miles*, or *Leagues*.



How to lay off an Angle *by the* Line of Chords.

DRaw a *Line* at pleaſure, as A B; and from the *point* A let it be required to protract an *Angle* of 41 *deg.* 24 *min.* Firſt extend the *Compaſſes* upon the *Line of Chords*, from the beginning thereof to 60 *deg.* always; and with this diſtance ſetting one Foot upon the *point* A, with the other deſcribe the pricked *Arch* BC: Then with your *Compaſſes* take 41 *deg.* 24 *min.* (which is the quantity of the inquired *Angle*) out of the *Line* of *Chords*, from the beginning thereof to 41 *deg.* 24 *min.* Keeping the *Compaſſes* at this diſtance,

if you ſet one Foot thereof upon B, the other will reach upon the *Arch* to C. Laſtly, draw the *Line* A C. So the *Angle* C A B ſhall contain 41 *deg.* 24 *min.*

To find the Degrees *contained in an* Angle.

Suppoſe C A B were an *Angle* given, and that it were required to find the *Quantity* thereof. Open your *Compaſſes*, as before, to 60 *deg.* of your *Chord*; and placing one Foot in A, with the other deſcribe the *Arch* B C. Then take in your *Compaſſes* the *Diſtance* C B, and meaſuring that Extent upon the *Line* of *Chords*, from the beginning thereof, you ſhall find it reach 41 *deg.* 21 *min.* which is the Quantity of the inquired *Angle*.

If any *Angle* given or required ſhall contain above 90 *degrees*, you muſt then meaſure it at twice, by taking firſt the *Chord* of 90, and then the Remainder.

The ſeveral *Caſes* of *Right-lin'd Triangles*, may not only be applied to *Navigation*, but alſo in the taking of *Heights*, as is ſhewn elſewhere.

In the reſolving of *Plain Triangles* there are 12 *Caſes*, of which I will inſiſt in their order.

CHAP III.

Of Right-Angled Plain Triangles.

CASE I.

In a Right-Angled Plain Triangle, *the* Baſe *and the* Angle *at the* Baſe *being given, To find the* Perpendicular.

Suppoſe that the *Line* C A (in the following *Figure*) in the *Right-Angled Triangle* were a *Tree*, *Tower*, or *Steeple*, and that you would know the *Height* thereof; you muſt obſerve with your *Inſtrument* the *Angle* C B A, and meaſure the *Diſtance* B A.

So have you in the *Right-Angled Triangle* A B C, the *Baſe* 405 *Foot*, and the *Angle* at the *Baſe* 32 *deg.* and it is required to find the *Perpendicular* A C.

Now becauſe the *Angle* C B A is given, the *Angle* B C A is alſo given, it being the *Complement* of the other to 90 *deg.* and therefore the *Angle* B C A is 58 *degrees*: Then to find the *Perpendicular* C A, the Proportion is,

As the Sine *of the* Angle B C A 58 deg.	9928420
Is to the Logarithm *of the* Side B A 405 Foot	2607455
So is the Sine *of the* Angle C B A 32 deg.	9724210
The Sum *of the Second and Third added*	12331665
The firſt Number *ſubtracted from that* Sum	9928420
To the Logarithm *of the* Side C A	2403245

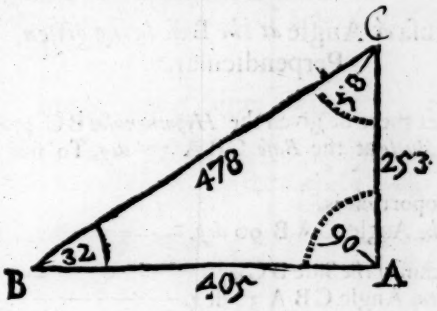
The *Number* anſwering to this *Logarithm* 2403245, is 253 Feet, and that is the Length of the *Side* C A, or the *Height* of the *Tree*, *Tower*, or *Steeple*, which was required.

A General Rule.

In all *Proportions* wrought by the *Logarithms*, you muſt obſerve this for a *General Rule*, (*viz.*) To add the ſecond and third *Numbers* together, and from the Sum of them to ſubtract the firſt *Number*, ſo ſhall the Remainder anſwer your *Queſtion* demanded. As by the former Work you may perceive, where the *Logarithm* of the *Side* B A 2607455 (which is the ſecond *Term*) is added to the *Sine* of the *Angle* C B A 9724210 (which is the third *Term*,) and from the Sum of them, namely from 12331665, is ſubtracted 9928420, the Sine of the *Angle* B C A, which

is

is the first *Number*, and there remaineth 2,403245, which is the *Logarithm* of 253, and that is the *Length* of the *Side* required.



To resolve the same Work *by the* Line *of* Sines *and* Numbers.

YOU may work these *Proportions* by the help of the *Line* of *Sines*, *Tangents*, and *Numbers*, on your *Scale*, the *Proportion* being as before.

Place here the Line *of* Numbers, Sines, *and* Tangents.

Therefore if you set one Foot of your *Compasses* at 58 *deg.* in the *Line* of *Sines*, and extend the other Foot to 405 in the *Line* of *Numbers*, the same will reach from the *Sine of* 32 *deg.* to 253 in the *Line* of *Numbers*, which is the *length* of the *Side* A C, which was required.

Or otherwise, Extend the *Compasses* from the *Sine* of 58 *deg.* to the *Sine* of 32 *deg.* in the *Line* of *Sines*; the same *Extent* will reach from 405 in the *Line* of *Numbers*, to 253, as before.

CASE II.

The Base *and the* Angle *at the* Base *being given, To find the* Hypothenusa.

IN the same *Triangle* A B C, let there be given (as before) the *Base* A B 405 Foot, and the *Angle* A B C 32 *deg.* and let it be required to find the *Hypothenusa* B C. Now because the *Angle* C B A is given, the other *Angle* B C A is also given; and the Proportion is,

As the Sine *of the* Angle B C A 58 deg.	——	9,928420
To the Logarithm *of the* Side 405 Foot	——	2,607455
So is the Sine *of the* Angle C A B 90 deg.	——	10,000000
The Sum *of the second and third* Number	——	12,607455 *added.*
To the Logarithm *of the* Side B C	——	2,679035

The *Number* answering to this *Logarithm* is 477; and so many *Feet* is the *Hypothenusa.*

By the Line *of* Numbers *and* Sines.

EXtend the *Compasses* from the *Sine* of 58 *deg.* to 405 in the *Line* of *Numbers*; the same Extent will reach from the *Sine* of 90 *deg.* to 477 in the *Line* of *Numbers*; and that is the *Length* of the *Side* B C. Or you may extend the *Compasses* from the *Sine* of 58 *deg.* to 90 *deg.* the same Extent will reach 405 to 477, as before.

CASE

CASE III.

The Hypothenuſa *or* Angle *at the* Baſe *being given, To find the* Perpendicular.

IN the ſame *Triangle* let there be given the *Hypothenuſal* B C 478 *Feet, Poles, Miles,* or *Leagues,* and the *Angle* at the *Baſe* C B A 32 *deg.* To find the *Perpendicular* C A.

The Proportion is,

As the Sine *of the* Angle C A B 90 *deg.* —— 10,000000

Is to the Logarithm *of the* Side B C 478 —— 2,679428

So is the Sine *of the* Angle C B A 32 deg. —— 9,724210

To the Logarithm *of the* Side A C 253 —— 2,403638

The *Number* anſwering to this *Logarithm* is 253, and that is the Length of the *Side* C A in *Feet, Poles, Miles,* or *Leagues.*

Here the *Work* is ſomething abbreviated; for the *Angle* C A B being a *Right Angle,* and being the firſt *Term* when the ſecond and third *Terms* are added together, the firſt is eaſily ſubtracted from it, by cancelling the *Figure* next your left hand, as you ſee in the *Example*; and ſo the reſt is the *Logarithm* of the *Number* ſought.

By the Line *of* Sines *and* Numbers.

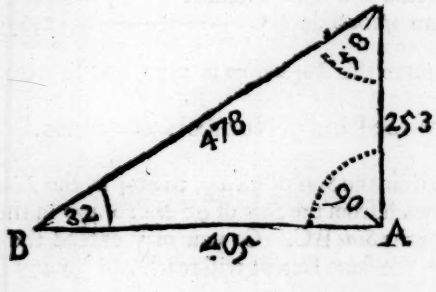
EXtend the *Compaſſes* from the *Sine* of 90 *degrees,* to 478; the ſame Extent will reach from the *Sine* of 32 *degrees,* to 253.

Or, extend the *Compaſſes* from the *Sine* of 90 *degrees,* to the *Sine* of 32 *degrees*; the ſame Extent will reach from 478 to 253, and that is the *Side* C A.

CASE IV.

The Hypothenuſal *and* Angle *at the* Baſe *being given, To find the* Baſe.

LET there be given in the *Triangle* the *Hypothenuſal* B C, and the *Angle* at the *Baſe* C B A; and by conſequence the *Angle* B C A the *Complement* of the other to 90 *degrees*: then to find B A, the Proportion is,



As the Sine of 90 deg. C A B —— 10,000000

To the Hypothenuſal C B 478 —— 2,679428

So is the Sine *of the* Angle A C B 58 —— 9,928420

To the Logarithm *of the* Baſe A B —— 2,607848

The

The neareſt *Number* anſwering to 2, 607848 is 405 : and ſo many *Foot* or *Poles*, *Miles* or *Leagues* is the *Baſe* A. B.

In the *Art* of *Navigation*, we may call one of the *Sides*, as A. B. the *Longitude*, or *Meridian Diſtance*; the other the *Difference* of *Latitude* as C. A; and the *Hypothenuſal*, the *Diſtance*, as C. B.

By the Line *of* Sines *and* Numbers.

THE *Angle* given, as before, Extend the *Compaſſes* from the *Sine* of 90 *deg.* unto 478. the ſame Extent will reach from the *Sine* of 58 *deg.* to 405 in the *Line* of *Numbers*.

Or, Extend the *Compaſſes* from the *Sine* of 90 *deg.* to the *Sine* of 58 *deg.* the ſame Extent will reach from 478 to 405, which is the *Length* of the *Baſe* A. B.

CASE. V.

Let the Perpendicular *be the* Difference *of* Latitude 253 Leagues, *and the* Angle *at* C, S. W. *by* W. 1 deg. 45 min. Weſterly, *or or* 58 deg. *Let it be given to find the* Hypothenuſal *or* Diſtance *upon the* Rhomb.

IF the *Perpendicular* or *Difference* of Latitude 253. *Leagues* A C be given, and the *Angle* at A C B. *S. W. by W.* 1 *deg.* 45 *Weſterly*, or 58 *deg.* Then by conſequence the *Angle* A B C, or *Complement* of the *Rhomb* is alſo given; taking it out of 90 *deg.* then the *Hypothenuſal* may be found thus.

As the Sine Complement *of the* Rhomb 32 deg. *the* Angle *at* B.	9,724210
Is to the Logarithm *of the* Difference *of* Latitude 253	12,403121
So is the Sine *of the* Angle *or* Radius 90 deg.	10,000000
To the Logarithm *of the* Hypothenuſal, *or* Diſtance ſailed, 477	2, 678911

Here becauſe the *Angle* C A B is a *Right Angle*, or 90 *Degrees* the *Radius*, and comes in the third place, I therefore only put an *Unite* before the ſecond *Term*, and ſo ſubtract the firſt *Term*, and the Remainder is 2, 678988; the *Abſolute Number* anſwering thereunto is 478, the *Side* required.

By the Line *of Numbers.*

EXtend the *Compaſſes* from the *Sine* of 32 *deg.* to 253 *deg.* the ſame *Diſtance* will reach from the *Sine* of 90 *deg.* to 477 the *Side* required.

Or, The *Diſtance* between the *Sine* of 32 *deg.* and 90 *deg.* will be equal to the *Diſtance* between 253 and 477, and giveth the *Side* required.

CASE. VI.

The Hypothenuſal *or* Diſtance *Sailed, and the* Perpendicular *or* Difference *of* Latitude *given, To find the* Rhomb *or* Angle A B C.

IN the foregoing *Triangle*, there is given the *Hypothenuſal* or *Diſtance* ſailed, C B 478 *Leagues*, and the *Perpendicular* 253 *Leagues*, the Difference of *Latitude*, and it is required to find the *Angle* A B C, the *Rhomb* between the *South* and the *Weſt*.

As

As the Logarithm *of the* Hypothenuſal C B 478 Leagues —— 2,679428

Is to the Right Angle *or* Radius 90 deg. C A B —— —— 10,000000
So is the Logarithm *of the* Perpendicular 253 A C —— —— 2,403121

To the Complement Sine *of the* Rhomb, *or* Sine *of the* Angle A B C 31 deg. 57 min. —— —— —— —— —— —— 9,723693

The neareſt *Logarithm* anſwering to 9, 723693, is the *Sine* of 31 *deg.* 57. *min.* which deducted from 90 *deg.* there remaines the *Angle* of the *Rhomb* 58 *deg.* 3. *min.* or *S. W. by W.* 1 *deg.* 48 *Weſterly.*

By the Line *of* Numbers.

EXtend the *Compaſſes* from 478, to the *Sine* of 90; the ſame *Diſtance* will reach from 253, to 32 *deg. fere.*

Or, Extend the *Compaſſes* from 478. to 253; the ſame Extent will reach from the *Sine* of 90 to the *Sine* of 32 *deg. fere,* which is the required *Angle* A B C, and the *Complement* of the *Rhomb.*

CASE. VII.

The Hypothenuſal, *and the* Parallel *of* Longitude *given, To find the* Rhomb *or* Courſe *Sailed.*

IN the foregoing *Triangle* there is given the *Hypothenuſal* or *Diſtance* Sailed, C B 478 *Leagues,* and the *Parallel* of *Longitude* or *Baſe* 405 Leagues, to find the *Courſe* or *Rhomb* ſailed, or the *Angle* A C B.

As the Hypothenuſal *or* Diſtance *ſailed* 478 C B —— —— —— 2,679428

To the Right Angle C A B Radius *or* Sine *of* 90 *deg.* —— —— 10,000000
So is the Parallel *of* Longitude, *or* Baſe A B 405 Leagues —— 12,607455

To the Sine *of the* Angle *of the* Rhomb *or* Courſe *ſailed* 57 *deg.* 55 *min.* or *S. W. by W.* 1 *deg.* 40 *Weſterly.* —— —— 9,928027

By the Lines *of* Sines *and* Numbers.

EXtend the *Compaſſes* from 478 in the *Line* of *Numbers,* to the *Sine* of 90 deg. the ſame Extent will reach from 405, to the *Sine* of 58 *deg. ferè.*

Or, Extend the *Compaſſes* from 478 to 405; the ſame Extent will reach from the *Sine* of 90, to the *Sine* of 58 *deg. ferè,* A C B, the *Angle* of the *Rhomb* or *Courſe* ſailed, which was requried.

CHAP.

CHAP. IV.

Of Oblique-Angled Plain Triangles.

CASE I.

Having two Angles, *and a* Side *oppoſite to one of them, To find the* Side *oppoſite to the other.*

IN the *Triangle* QRS, is given the *Angle* QSR, 25. *deg.* 30 *min.* and the *Angle* QRS, 45. *deg.* 20 *min.* and the *Side* QS, 305 *Feet*; And it is required to find the *Side* QR.

Here note, That in *Oblique-Angled Plain Triangles*, as well as in *Right-Angled* the *Sides* are in proportion one to the other, as the *Sines* of the *Angles* oppoſite to thoſe *Sides*: Therefore,

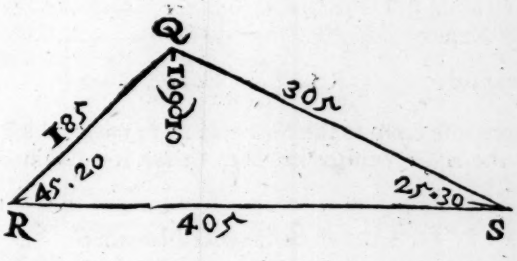
As the Sine *of the* Angle QRS 45 *deg.* 20 *min*	9, 851997
Is to the Logarithm *of the* Side QS 305	2, 484299
So is the Sine *of the* Angle QSR 25 deg. 30 min.	9, 633984
The Sum *of the ſecond and third* Terms	12, 118283
The firſt Term *ſubtracted*	9, 851997
To the Logarithm *of the* Side QR	2, 266286

The neareſt *Abſolute Number* anſwering to this *Logarithm* is 184; and ſo many *Feet* is the *Side* QR.

By the Line *of* Sines *and* Numbers.

THE *Line* of *Sines* and *Numbers* will reſolve the *Triangle* by the ſame manner of Work, as in the other before. For if you extend the *Compaſſes* from the *Sine* of 45 *deg.* 20 *min.* to 305 *Foot*, the ſame diſtance will reach from 25 *deg.* 30 *min.* to 184 *Foot*, and ſo much is the *Side* QR.

Or, Extend the *Compaſſes* from the *Sine* of 45 *deg.* 20 *min.* to 25 *deg.* 30 *min.* the ſame Diſtance will reach from 305 to 184, the *Length* of the *Side* inquired.



In like manner if the *Angle* QRS, 109 *deg.* 10 *min.* and the *Angle* QRS 45 *deg.* 20 *min.* and the *Side* QS 305 *Foot*, had been given, and the *Side* RS required, the manner of Work had been the ſame: For,

As the Sine *of the* Angle QRS, 45 *deg.* 20 *min.* —— 9, 851997

Is to the Logarithm *of the* Side QS 305 —— 2, 484299
So is the Sine *of* RQS 109 deg. 10 min. (*or* 70 deg. 50 min.) —— 9, 975233

The Sum *of the second and third* Terms —— 12, 459532
The first Term *subtracted* —— 9, 851997

To the Logarithm *of the* Side RS 405 —— 2, 607535

The *Absolute Number* answering to this *Logarithm* is 405, and so much is the *Side* R. S.

In this Case, because the *Angle* RQS is more than 90 *Degrees*, you must therefore take the *Complement* thereof to 180 *deg.* so 109 *deg.* 10 *min.* being taken from 180 *deg.* there remains 70 *deg.* 50 *min.* whose *Sine* is the same with 109 *deg.* 10 *min.* And so you must work with all *Angles* above 90 *Degrees.*

By the Line *of* Numbers *and* Sines.

EXtend the *Compasses* from the *Sine* of 45 *deg.* 20 *min.* to 305 *Feet*, the same Distance will reach from 70 *deg.* 50 *min.* to 405.

Or the *Compasses* extended from the *Sine* of 45 *deg.* 20 *min.* to 70 *deg.* 50 *min.* the same Extent will reach from 305, to 405 in the *Line* of *Numbers*, which is the *Side* RS required.

CASE II.

Two Sides *and an* Angle *opposite to one of them being given, To find the* Angle *opposite to the other.*

IN the same *Triangle*, let there be given the *Side* QS 305, and QR 185 *Feet*, together with the *Angle* QSR 25 *deg.* 30 *min.* and let it be required to find the *Acute Angle* QRS. The Proportion is,

As the Logarithm *of the* Side QR 185 —— 2, 267172

Is to the Side *of the* Angle QSR 25 deg. 30 min. —— 9, 633984
So is the Logarithm *of the* Side QS 305 —— 2, 484299

The Sum *of the second and third* Numbers —— 12, 118283
The first Number *subtracted from the* Sum —— 2, 267172

To the Sine *of the* Angle QRS 45 *deg.* 13 *min.* —— 9, 851111

The neareſt degree anſwering to this *Sine* is 45 *deg.* 13 *min.* which is the *Angle* required QRS, If the *Angle* required had been *Obtuſe*, it would have been 134 *deg.* 47 *min.*

By the Line *of* Sines *and* Numbers.

EXtend the *Compaſſes* from 185, to 25 *deg.* 30 *min.* the ſame Diſtance will reach from 305, to 45 *deg.* 13 *min.* the *Angle* QRS.

Or, Extend the *Compaſſes* from 185, to 305; the ſame Extent will reach from 25 *deg.* 39 *min.* to 45 *deg.* 13 *min.* as before.

CASE.

CASE III.

Having two Sides, *and the* Angle *contained between them given, To find either of the other* Angles.

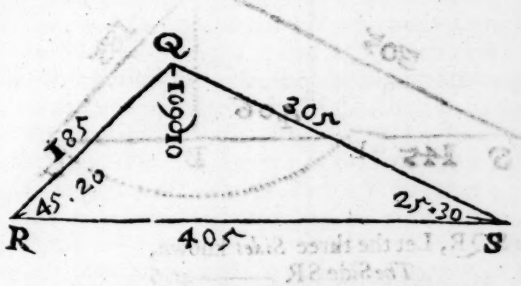
IN the ſame *Triangle*, Suppoſe there were given the *Side* RS 406, and the *Side* RQ 185, and the *Angle* comprehended by them, namely the *Angle* at R, 45 *deg.* 20 *m.* and it were required to find either of the other *Angles*.

Firſt, Take the *Sum* and *Difference* of the two *Sides* given; their *Sum* is 591, and their *Difference* is 221. Then knowing, that the three *Angles* of all *Right-lin'd Triangles*, are equal to two *Right Angles*, or 180 *deg.* (by the 17th *Theor.* of *Chap.* 3.) Therefore the *Angle* SQR being 45 *deg.* 20 *min.* if you ſubtract this *Angle* from 180 *deg.* the Remainder will be 134 *deg.* 40 *min.* which is the *Sum* of the two unknown *Angles* at Q and S; the half thereof is 67 *deg.* 20 *min.*

			deg.	*min.*
The Side RS —406 *Paces.*		*Two* Right-Angles —	180	00
The Side RQ —185 *Paces.*		*The* Angle *at* R —	45	20
The Sum — 591	*of the* Sides *given*,	*The* Sum *of the two oppoſite* Angles.	134	40
The Difference — 221	RS *and* RQ.	*The* Half-Sum —	67	20

The *Sum* and *Difference* of the *Sides* being thus found, and alſo the *Half-Sum* of the two unknown *Angles*, The Proportion by which you muſt find the *Angles* ſeverally is,

As the Logarithm *of the* Sum *of the* Sides 591 —	2771587		
Is to the Logarithm *of the* Difference *of the* Sides 221 —	2344392		
So is the Tangent *of the* Half-Sum *of the two unknown* Angles 67 deg. 20 min. —	10379213		
The Sum *of the ſecond and third* Number —	12723605	½ *Sum*	67 20
The firſt Number *ſubtracted from the* Sum —	2771587	*Tang.*	41 50
The Tangent *of* 41 deg. 50 min. —	9952018		109 10
Which added to the Half-Sum, *makes* —	109 *deg.* 10 *min.* Greater Angle.	*Leſſer Angle*	25 30
The greater of the Angles *required*, — *Subtract* 41 deg. 50 min. *from the* Half-Sum, *leaves the leſſer* Angle *at* S	25 *deg.* 30 *min.* Leſſer Angle.		



By the Line *of* Tangents *and* Numbers.

EXtend the *Compaſſes* from the *Sum* of the *Sides* 591, to the *Difference* of the *Sides* 221; the ſame Extent upon the *Line* of *Tangents* will reach from 67 *deg.* 20 *min.* the *Half-Sum*, to the *Tangent* of 41 *deg.* 50 *min.*

CASE. IV.

Two Sides *and their* Containing Angle *given, To find the third* Side.

THere is given R S 406 *Paces* and R Q 185 *Paces*, and the *Angle* at R 45 *deg.* 20 *min.* By the 10th *Caſe*, to find the *Side* Q S.

As the Sum *of the* Sides *given* R S and R Q 591 *Paces*		2771587
Is in proportion to their Difference R S & R Q 221		2344392
So is the Tangent *of the* Half Sum *of the two oppoſite* Angles Q & S *unknown*	67 deg. 20 min.	10379213
		12723605
To the Tangent *of*	41 *d.* 50 *m.*	9952018
Which added to the Half Sum	67 20	
gives the greater Angle *at* Q *required*	109 10	

Then ſay,

As the Sine *of the* Angle *found* 109, *or* 70 *deg.* 50 *min.*		9,975133
Is in proportion to his oppoſite Side R S 406 *Paces*		2,608526
So is the Sine *of the* Angle *given at* R 45 *deg.* 20 *min.*		9,851997
To his oppoſite Side *required*, Q S 306 Paces *ferè*		12,460523
The Logarithm *of the* Side *required*		2,485290

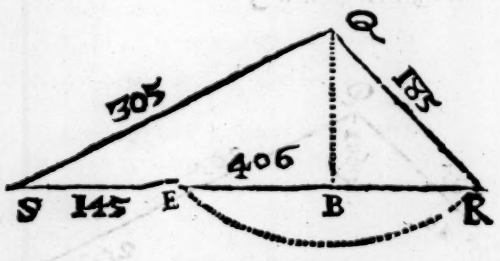
By the Line *of* Sines *and* Numbers, *To find the third* Side.

EXtend the *Compaſſes* from the *Sine* of 70 deg. 50 min. to R S 406 *Paces*; the ſame Extent will reach from the *Sine* of 45 deg. 20 min. to the *Side* 305.

Or, Extend the *Compaſſes* from the *Sine* of 70 deg. 50 min. to the *Sine* of 45 deg. 20 min. the ſame Diſtance will reach from 406, to 305 *Paces*, which is the *Length* of the *Side* Q S, which is required.

CASE V.

Three Sides *of an* Oblique Triangle *being given, To find the* Angles.



IN this *Triangle* S Q R, Let the three *Sides* known,

The Side S R	406
The Side S Q	305
The Side Q R	185

And it is required to find the three *Angles*.

To performe this, you muſt firſt let fall a *Perpendicular* from the *Point* Q, upon the *Side* R S, which you may do by ſetting one foot of your *Compaſſes* in the *Point* Q, and open the other to the *Point* R, draw the *Arch* R E. and divide the *Space* E R, into two equal parts; and ſo the *Perpendicular* will fall upon the *Point* B.

To

To perform this by *Numbers.*

As the greater Side *or* Base SR, 406	2,608526
To the Sum *of the two leſſer* Sides 490	2,690196
So is the Difference *of theſe two* Sides 120	2,079181
To the Part SE (*cut off by the* Arch RBE) 145	4,769377
	2,608526
	2,160851

This ſubtracted from the whole *Line* 406, leaves for the part within the *Arch* 261; the half thereof is $130\frac{1}{2}$, which is the Place B where the *Perpendicular* will fall, reckoned from the *Angle* R; and by this *Perpendicular* you have divided the *Triangle* into two *Right-Angles*, whoſe *Sides* are known: For RB being $130\frac{1}{2}$, ſubtracted from the whole *Line* SR 406, leaves for the remaining Part $275\frac{1}{2}$. Now having thoſe two *Sides* of theſe two *Right-Angled Triangles*, and the two firſt given *Sides*, 305 and 185, being the two *Hypothenuſals* thereof, you may by the oppoſition of *Sides* to their *Angles*, (as in the 7 *Caſe* of *Right-Angled Triangles*) find the required *Angles*.

By the Line *of* Sines *and* Numbers.

EXtend the *Compaſſes* from 406 to 490; the ſame Diſtance will reach from 120, to 145 SE *Leagues*, the *Side* required.

CHAP. V.

Of the affection of Spherical-Triangles.

A *Spherical Triangle* is deſcribed on the ſurface of the Sphere.

The Sides of a Spherical Triangle, are the Arches of three great Circles of the Sphere, mutually interſecting each other.

A great Circle divides the Superficies of the Sphere into two equal parts.

The Angles of a Spherical Triangle, are meaſured by an Arch of a great Circle interſecting the containing Sides at Right Angles, whoſe Pole is the Angular Point.

The Sum of the three Sides of a Spherical Triangle are leſs then two Semicircles.

The Sum of the three Angles of a Spherical Triangle, are greater than two Right-Angles and leſs than ſix.

Spherical Triangles are either *Right-Angled* or *Oblique-Angled.*

A Right-Angled Spherical Triangle, is that which hath one Right-Angle at the leaſt.

An Oblique-Angled Spherical Triangle, is that which hath never a Right-Angle.

In a Right-Angled Spherical Triangle, the two Sides containing the Right Angle are called *Leggs*, and the Side oppoſite to the Right-Angle the *Hypothenuſe.*

In a Right-Angled Spherical Triangle, the Oblique Angles are of the ſame kind with their oppoſite Leggs: That is, if either of the Leggs be a Quadrant, the oppoſite Angle is a Right Angle; if either of the Leggs be leſs than a Quadrant, the oppoſite Angle is acute; and if either of the Leggs be greater than a Quadrant, the oppoſite Angle is Obtuſe.

In a Right-Angled Spherical Triangle, if both the Leggs be of one kind, that is both greater or both leſs than a Quadrant, the *Hypothenuſe* is leſs than a Quadrant; but if the Leggs be of different kinds, the *Hypothenuſe* is greater than a Quadrant, and if the Leggs be Quadrants, the *Hypothenuſe* is alſo a Quadrant.

An Oblique-Angled Spherical Triangle is either Acute-Angled or Obtuſe-Angled.

An Accute-Angled Spherical Triangle, is that which hath three acute Angles.

An Obtuſe Angled Spherical Triangle, hath all its Angles either Obtuſe or mixt, *viz.* Acute and Obtuſe.

The three Sides of an Acute-angled Triangle, are each of them leſs than Quadrants.

In *Spherical Triangles* there are 28 *Caſes*, 16 in *Right-angled Triangles*, and 12 in *Oblique-angled Triangles*.

CHAP. VI.

Containing the Doctrine of Right-angled Spherical Triangles.

CASE I.

The Leggs *given, To find the* Hypothenuſe.

The Proportion.

As *Radius*,
To *Sine Compl.* of one of the Leggs,
So is the *Sine Compl.* of the other Leg,
To the *Sine Compl.* of the *Hypothenuſe* required.

Example.

In the *Triangle* ABC, there is given,

	deg.	*min.*	
AB	60	07	} AC required.
BC	51	32	}



The Operation.

As *Radius*				10,000000
To *Sine Compl.* AB	60 *deg.*	07 *min.*		9,697435
So is *Sine Comp.* BC	51	32		9,793832
To *Sine Comp.* AC	71	57		19,491267

CASE II.

The Leggs *given, To find one of the* Oblique Angles.

The Proportion.

As *Radius*,
To the *Sine* of the adjacent *Legg*;
So is the *Tangent* of the oppoſite *Legg*:
To the *Tangent Compl.* of the *Angle* required.

CASE. III.

One of the Leggs *and an adjacent* Angle *being given, To find the oppoſite* Legg.

The Proportion.

As *Radius*,
To the *Sine* of the adjacent *Legg*:
So is the *Tangent* of the adjacent *Angle*:
To the *Tangent* of the *Legg* ſought.

CASE

CASE IV.

One of the Leggs *and an adjacent* Angle *being given to find the* Hypothenuſe.

The Proportion.

As *Radius*,
To the *Sine Compl.* of the adjacent *Angle*;
So is the *Tangent Compl.* of the adjacent *Legg*;
To the *Tangent Compl.* of the *Hypothenuſe* required.

CASE. V.

One of the Leggs *and the adjacent* Angles *being given, To find the oppoſite* Angle.

The Proportion.

As *Radius*,
To the *Sine Compl.* of the adjacent *Angle*;
So is the *Sine Compl.* of the adjacent *Side*;
To the *Sine Compl.* of the *Angle* required.

CASE. VI.

The Hypothenuſe *and one of the* Oblique Angles *being given, To find the adjacent* Legg.

The Proportion.

As *Radius*,
To the *Sine Compl.* of the given *Angle*;
So is *Tangent* of the *Hypothenuſe*;
To the *Tangent* of the *Legg* required.

CASE VII.

The Hypothenuſe *and one of the* Oblique Angles *being given, To find the* Legg *oppoſite to the given* Angle.

The Proportion.

As *Radius*,
To the *Sine* of the *Hypothenuſe*,
So is the *Sine* of the given *Angle*;
To the *Sine* of the *Legg* ſought.

CASE. VIII.

The Hypothenuſe *and one of the* Oblique Angles *being given, To find the other* Oblique Angle.

The Proportion.

As *Radius*,
To the *Sine Compl.* of the *Hypothenuſe*;
So is the *Tangent* of the given *Angle*;
To the *Tangent Compl.* of the *Angle* ſought.

CASE IX.

The Hypothenuſe *and one of the* Leggs *given, to find the other* Legg.

The Proportion.

As *Radius*,
To the *Sine* of the given *Legg*;
So is the *Sine Compl.* of the *Hypothenuſe*;
To the *Sine Compl.* of the *Legg* required.

CASE X.

The Hypothenuſe *and one of the* Leggs *given, To find the* Angle *adjacent to the given* Legg.

The Proportion.

As *Radius*,
To the *Tangent Compl.* of the *Hypothenuſe*;
So is the *Tangent* of the given *Legg*;
To the *Sine Compl.* of the *Angle* required.

CASE XI.

The Hypothenuſe *and one of the* Leggs *given, To find the* Angles *oppoſite to the given* Legg.

The Proportion.

As *Radius*,
To the *Sine Compl.* of the Hypothenuſe;
So is *Sine* of the given *Legg*:
To the *Sine* of the *Angle* required.

CASE XII.

One of the Oblique Angles *and the oppoſite* Legg *being given, To find the other* Legg; *it being known whether the* Legg *required be greater or leſs than a* Quadrant.

The Proportion.

As *Radius*,
To the *Tangent Compl.* of the given *Angle*;
So is the *Tangent* of the given *Legg*;
To the *Sine* of the *Legg* ſought.

CASE XIII.

One of the Oblique Angles *and the oppoſite* Legg *being given, To find the* Hypothenuſe; *it being known whether the* Hypothenuſe *be greater or leſs than a* Quadrant.

The Proportion.

As *Radius*,
To the *Sine Compl.* of the given *Angle*;
So is the *Sine* of the given *Legg*;
To the *Sine* of the *Hypothenuſe* required.

CASE XIV.

One of the Oblique Angles *and the opposite* Leg *being given, To find the other* Angle; *it being known whether the* Angle *sought be* Acute *or* Obtuse.

The Proportion.

As *Radius*,
To the *Sine* of the given *Legg*;
So is the *Sine Compl.* of the given *Angle*;
To the *Sine* of the *Angle* required.

CASE. XV.

The two Oblique Angles *being given, To find the* Hypothenuse.

The Proportion.

As *Radius*,
To the *Tangent Compl.* of one of the given *Angles*;
So is the *Tangent Compl.* of the other given *Angle*;
To the *Sine Compl.* of the *Hypothenuse* required.

CASE. XVI.

The two Oblique Angles *being given, To find one of the* Legs.

The Proportion.

As *Radius*,
To the *Sine Compl.* of one of the given *Angles*:
So is *Sine Compl.* of the other given *Angle*:
To the *Sine Compl.* of the *Legg* sought.

CHAP. VI.

Containing the Doctrine of Oblique-Angled Spherical Triangles.

CASE I.

Two Sides *and an* Angle *opposite to one of them being given, to find the other opposite Angle; If it be known whether the required* Angle *be* Acute *or* Obtuse.

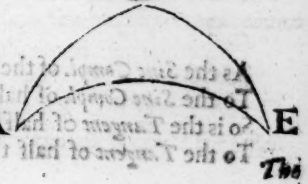
The Proportion.

As the *Sine* of the given *Side*,
To the *Sine* of the given *Angle* oppofite thereto;
So is the *Sine* of the other given *Side*;
To the *Sine* of the oppofite *Angle* required.

Example.

In the *Triangle* A D E there is given

A E D	29	55	} D A E required being Acute.
A D	34	59	
D E	60	10	



The Operation.

	deg.	min.	
As the *Sine* A D	34	59	9,758411
To *Sine* A E D	29	55	9,697874
So is *Sine* D E	60	10	9,938257
To *Sine* D A E	48	59	19,636131
			9,877720

CASE II.

Two Angles *and a* Side *opposite to one of them being given, To find the other opposite* Side, *if it be known, whether it be greater or less than a* Quadrant.

The Proportion.

As the *Sine* of a given *Angle*,
To the *Sine* of the *Side* opposite thereto;
So is the *Sine* of the other given *Angle*;
To the *Sine* of the opposite *Side* required.

CASE. III.

Two Sides *and their contained* Angle *being given, To find the opposite* Angles.

The Proportion.

As the *Sine* of half the Sum of the two given *Sides*,
To the *Sine* of half their *Difference*;
So is the *Tangent Compl.* of half the contained *Angle*;
To the *Tangent* of half the *Difference* of the opposite *Angles*.

And,

As the *Sine Compl.* of half the Sum of the the two given *Sides*,
To the *Sine Compl.* of half their *Difference*;
So is the *Tangent Compl.* of half the contained *Angle*,
To the *Tangent* of half the Sum of the opposite *Angles*.

Then to the half Sum of the opposite *Angles*, add their half *Difference*, the Sum is the greater of the two *Angles* sought: And from the half Sum of the opposite *Angles* subtract their half *Difference*, the remainder is the lesser of the opposite *Angles* required.

CASE. IV.

Two Angles *and the* Side *between them being given; To find the opposite* Sides.

The Proportion.

As the *Sine* of half the Sum of the two given *Angles*,
To the *Sine* of half their *Difference*;
So is the *Tangent* of half the *Side* between them;
To the *Tangent* of half the *Difference* of the opposite *Sides*.

And,

As the *Sine Compl.* of the half Sum of the two *Angles*,
To the *Sine Compl.* of half their *Difference*;
So is the *Tangent* of half the *Side* between them;
To the *Tangent* of half the Sum of the opposite *Sides*.

Note,

Note, That in the third and fourth *Cases* before-going, if the sum of the two given *Sides*, or two given *Angles* exceed 180 degrees, then take the *Complements* of those *Sides* or *Angles* to 180 deg. severally, instead of the *Sides* or *Angles* given; and the *Angles* or *Sides* produced by the *Operation*, are the *Compl.* of the *Angles* or *Sides* sought to 180 *Degrees*.

CASE V.

Two Sides *and an* Angle *opposite to one of them being given, To find the third* Side; *if it be known whether the* Angle *opposite to the other given* Side *be* Acute *or* Obtuse.

The Proportion.

First find the *Angle* opposite to the other given *Side*, by the first *Case* of *Oblique-angled Triangles*; *Then say*,

As the *Sine* of the *Difference* of the opposite *Angles*,
To the *Sine* of half the Sum of those *Angles*;
So is the *Tangent* of half the *Difference* of the two given *Sides*;
To the *Tangent* of half the *Side required*.

CASE. VI.

Two Angles *and a* Side *opposite to one of them being given, to find the third* Angle, *if it be known whither the* Side *opposite to the other given* Angle *be greater or less than a* Quadrant.

The Proportion.

First find the *Side* opposite to the other given *Angle*, by the second *Case* of *Oblique Angled Triangles*; Then say,

As the *Sine* of half the *Difference* of the opposite *Sides*,
To the *Sine* of half the *Sum* of those *Sides*.
So is the *Tangent* of half the *Difference* of the two given *Angles*:
To the *Tangent Compl.* of half the *Angle* sought.

CASE VII.

Two Sides *and an* Angle *opposite to one of them being given; To find the contained* Angle; *if it be known whether the* Angle *opposite to the other given* Side *be* Acute *or* Obtuse.

The Proportion.

First find an *Angle* opposite to the other given *Side*, by the first *Case*; *Then say*,

As the *Sine* of half the *Difference* of the two given *Sides*;
To the *Sine* of half the *Sum* of those *Sides*.
So is the *Tangent* of half the *Difference* of the opposite *Angles*
To the *Tangent Compl.* of half the *Angle* required.

CASE VIII.

Two Angles *and a* Side *opposite to one of them being given, to find the interjacent* Side; *If it be known whether the* Side *opposite to the other given* Angle, *be greater or less than a* Quadrant.

The Proportion.

First find the *Side* opposite to the other given *Angle*, by the 2d. *Case*; *Then say*,

As the *Sine* of half the *Difference* of the two given *Angles*,
To the *Sine* of half the *Sum* of those *Angles*;
So is the *Tangent* of half the *Difference* of the oppoſite *Sides*;
To the *Tangent* of half the *Side* required.

CASE IX.

Two Sides *and the contained* Angle *being given, To find the third* Side.

The Proportion.

As *Radius*,
To the *Sine Compl.* of the contained *Angle*;
So is the *Tangent* of the leſſer *Side*;
To the *Tangent* of an *Arch*.

If the given *Angle* be *Acute*, ſubtract this *Arch* from the greater of the two given *Sides*; but if the given *Angle* be *Obtuſe*, ſubtract it from the *Compl.* thereof to 180 deg. and note the *Remainder*.

Then ſay,
As the *Sine Compl.* of the *Arch* found,
To the *Sine Compl.* of the *Remainder*;
So is the *Sine Compl.* of the Leſſer of the containing *Sides*.
To the *Sine Compl.* of the *Side* required.

CASE X.

Two Angles *and the interjacent* Side *being given, to find the third* Angle.

The Proportion.

As *Radius*,
To the *Sine Compl.* of the interjacent *Side*,
So is the *Tangent* of the leſſer of the two given *Angles*.
To the *Tangent* of an *Arch*.

If the interjacent *Side* be greater than a *Quadrant*, ſubtract the *Arch* found from the greater of the given *Angles*, but if it be leſs than a *Quadrant*, ſubtract it from the the *Compl.* of the ſaid *Angle* to 180 deg. and Note the *Remainder*.

Then ſay,
As the *Sine Compl.* of the *Arch* found,
To the *Sine Compl.* of the *Remainder*;
So is the *Sine Compl.* of the leſſer *Angle*,
To the *Sine Compl.* of the *Angle* required.

CASE. XI.

Three Sides *given, To find an* Angle.

To perform this Caſe by the Logarithms, take this following Direction.

Firſt ſet down the two *Sides* containing the required *Angle*, and then the *Side* oppoſite thereto; Add the three *Sides* together, and take the half ſum thereof from the half ſum of the three *Sides*; Subtract the *Side* oppoſite to the *Angle* required, and ſubſcribe the Remainder. Then to the *Complement Arithmetical* of the *Sines* of the containing *ſides*, add the *ſines* of the half ſum and Remainder; Half the ſum of theſe four *Logarithms*, is the *ſine Compl.* of half the *Angle* required.

CASE

CASE XII.

Three Angles *being given, To find a Side.*

To perform this *Case*, take the *Compl.* of the greateſt *Angle* to 180 *degrees* which uſe inſtead of that *Angle*, then ſet down the two *Angles* adjacent to the required *ſide*, and then the *Angle* oppoſite thereto; Add theſe three *Angles* into one ſum, and take the half thereof, from this half ſum ſubtract the *Angle* oppoſite to the required *ſide*, and ſubſcribe the Remainder. Then to the *Complement Arithmetical* of the *ſines* of the two adjacent *Angles*, add the *ſines* of the half ſum and remainder; half the ſum of theſe four *Logarithms*, is the *Sine Compl.* of half the *ſide* required.

Only Note,

That if the greateſt *ſide* of the *Triangle* be required; This operation produces the *Complement* thereof to 180 *degrees*.

The End of the Third Book.

THE Compleat Sea Artist: OR THE ART OF NAVIGATION.

The Fourth Book.

CHAP. I.

Of Sailing by the Plain Chard, *and the Uncertainties thereof.*

THE *Art* of *Navigation*, is a Science directing by certain *Rules* to Steer a Ship through the Sea, from the one place to the other; and may not improperly be divided into two parts, namely, the *Common*, and the *Artificial Navigation*.

The *Common Navigation* requireth the Use of no *Instruments* but the *Compass* and *Sounding-Lead*, as chiefly consisting in *Practice* and *Experience* in the knowledge of *Lands* and *Points*, how they lie, and their Distance one from the other, in knowledge of *Depths* and *Shoales*, and varieties of *Grounds*, the *Course* and *Setting* of *Tydes* upon what *Point* of the *Compass* the *Moon* maketh *High-water* in each several place, and the like; which must be known partly by the Information of skilful *Pilots*, and Instructions in Books for that purpose, but far better by a Man's own Practice and Experience.

The *Artificial Navigation* useth, besides the foresaid *Common-Practice*, divers other *Instruments* and *Rules*, which they take from *Astronomy* and *Cosmography*. It is therefore needfull that every *Pilot* and *Officer*, that takes charge of any *Ship* or *Vessel* in this part of *Navigation*, be first and chiefly well instructed in the principal Points of the foresaid *Arts*; that is, that he know the Order and understand the Division of the *Sphere*

Sphere of the World, and the motions of the Heavens; Together with the contriving or making and uſe of Inſtruments, as I have ſhewn briefly in the *Second Book*. For without this Knowledge it is impoſſible to perform Great Voyages by the Sea. In regard this Knowledge may be attained to, by good Inſtruction, we have ſet forth the ſame in this *Treatiſe*, for the benefit of ſuch young Sea-Men, as are deſirous to be Sea-Artiſts or Navigators, as clearly and plainly as the brevity of the ſame could permit.

The Defects and Imperfections of this Art are many; partly in the *Skil* or *Theorick*, partly in the *Practick*.

After a long Voyage, the Ship ſuppoſed to be near the *Shore*, the Commander or Maſter requires from his Mates an account of their Judgment how the *Land* or *Cape* bears from them, and the Diſtance from it. He that comes neareſt the Truth is ſuppoſed to have kept the beſt Reckoning. I have known ſome, that have ſcarce been able to number five figures, have gone nearer the Truth than the beſt Artiſt in the Ship; but they have been wonderfully miſtaken (to my knowledge) in other Voyages.

I went a Voyage to *Barbadoes* in the *Rainbow*, and took our Reckoning from *Lundy*, in the Mouth of *Severn*; and in the Ship were twelve Practitioners that kept an account; eleven of them kept it by the *Plain Chart*, and my ſelf made uſe of *Mercator* and Mr. *Wright's Projection*. When we came in the *Latitude* (which was 400 Leagues from the *Iſland*) every man was ready to give his Judgment of his Diſtance off the *Barbades*. But they all fell wonderfully ſhort of the Truth; for he that ſhould have had the beſt Reckoning, was 300 *Leagues* ſhort, and moſt of all the reſt was 268 and 250 *Leagues*; and he that was accounted an excellent Artiſt aboard the Ship was 240. But by the Reckoning kept by *Mercator's Chart*, there wanted but three *Leagues* ſhort of the true Diſtance of the *Iſland*.

In the ſame Ship, going from thence to *Virginia*, they alſo fell ſhort, by the ſame way of Account by the *Plain Chart* 90 *Leagues* the neareſt; and thoſe that were adviſed to keep it by *Mercator*, found it to come but 4 or 5 *Leagues* ſhort of the *Cape* of *Virginia*: But coming from thence home, they got their Credit again coming all within 30 *Leagues* of the true Diſtance from the ſhore.

But we find that there is near 180 *Leagues* difference Error, between the *Meridian* of *Barbadoes* and *Lundy*, and much more in the Diſtance; and in ſome *Charts* about 620 *Leagues* Error, in the Diſtance between *Cape Fortuna*, the *South Cape* of *Anian*. Theſe Errors may be aſcribed partly to the uncertainty of the *Longitude*, and partly unto the *Plain Chart*, and Sailing by it, which makes ſome Places nearer than they are, and other Places far more diſtant than they are, and ſcituated much out of their true *Courſe* or *Rhomb*.

Secondly, Men many times commit great Errors in bad Steerage, and careleſs looking to the Compaſs; for I have known many Sea-men when their Trike at Helm hath been out, and the *Log* hove, they have told the Maſter or his Mate, they have Steer'd half a Point a Weather the Courſe; beſides, the Points of the *Needle* or *Wyers* being touched by the *Load-ſtone*, are ſubject to be drawn aſide by the *Guns* in the *Steerage*, or any *Iron* near it, and liable to Variation, and do not ſhew the true *North* and *South*, which ought continually to be obſerved by a good *Azimuth Compaſs*, (ſuch a one you have deſcribed, by which I ſurvey *Land* in the following *Treatiſe*:) ſo the Variation ought to be carefully allowed.

Beſides, on *Land* there is a difference in the ſame *Place*, as Mr. *Gunter* in his *Obſervations* at *Limehouſe*, for the finding the Variation, found it half a *Degree* more, and in other Places of the ſame Ground leſs and *Metius* ſaith, he hath found a *Degree* or two difference. This difference at *Land* muſt needs ſhew the uncertainty we have at Sea. Beſides, many times the Ship is carried away by unknown *Currents*, which when they be diſcovered by their *Ripplings*, as alſo ſome by reaſon of *Trade-Winds*, we ſet them in our *Journal*.

I found 11 deg. in a Field at St. George's and Briſtol being four miles diſt. and I made five Obſervations, as in p. 330. *and differ. half of a deg. only.*

Currents are a means of great miſtakes in keeping of a *Reckoning*; for Captain *Luke Fox* in his *North-Weſt* Diſcoveries, and the reſt complained fearfully of the faſt *Lands* of Ice upon thoſe Coaſts, that ſo alters the Current, that in ſome places they cannot make good their Courſe they ſteer upon by three Points; eſpecially in *Davis* his *Straights*, where ſteering *Eaſt*-by-*South*, they ſcarce could make good *South-Eaſt-by-South*, which is four Points of the *Compaſs*

I have

I have alſo perceived a good Current to ſet to the Eaſt South Eaſt, about the *Weſtern Iſlands*, and the *Madera's*, in ſeveral Voyages I have made to the *Weſt-Indies*; but more eſpecially I have obſerved it in my laſt Voyage to *Barbadoes*. I went out of *England* in Company with Captain *Jeremy Blackman*, in the *Eagle* bound to the *Eaſt-Indies*, and a *Dutch* Ship in his Company, and one of *Plymouth* for the *Iſle* of *May*: So we kept Company together as far as the *Madera's*, but intended not to ſee it that Voyage; for we reckoned our ſelves 25 Leagues, and ſome more to the *Weſtward* of the Meridian of the *Madera's*: But being in the Latitude near it, we eſpied the Land; and being becalm'd, drove with the Current by the *Eaſtern* end of the Iſland, betwixt *Porto Sancto*, and the *Deſarts* or *Rocks* that ly off from that end. I compared Reckoning with moſt abord each Ship that kept account, and found ſome 30 Leagues to the *Weſtward* of the Iſland; and thereby and in five Voyages made before that way, knew by experience there is a Current ſets ſtrongly near the Iſland East South East, Beſides ſeveral Ships of *London* and the *Weſt-Country* have miſt it. *Snellius* inſtanceth, That one of good repute, ſailing out of *Holland*, miſt it twice.

How we keep our Reckoning.

The firſt and moſt uſeful Queſtion in *Navigation*, is this; By the knowledge of the *Rhomb* or *Courſe* you ſailed upon, and the *Diſtance* of *Miles* or *Leagues* that you ſailed thereon, to know your difference of *Latitude* and *Longitude* (that is, how much you are Northerly or Southerly in reſpect of *Latitude*, or Eaſterly or Weſterly in reſpect of *Longitude*.) This is the moſt ordinary manner of keeping of Account by moſt Maſters and Mates, of the Ships Way; which is called the *Dead Reckoning*.

And to keep this account, firſt you ſee, That the knowledge of the *Rhomb* they ſailed, is always ſuppoſed to be had off the *Log-Board*, ſuppoſing the *Compaſs* by which we ſteer, either doth or ſhould ſhew the ſame exactly; and ſo you have the *Diſtance* in *Miles* and *Leagues*, put down every half Watch upon the *Log-Boards*. Therefore we will firſt *Queſtion*, and reſolve it by the *Traverſe-Table* following, and alſo by the *Traverſe-Scale* in the fifth Chapter of the ſecond Book. (I have ſhew'd it by the *Synical Quadrant* already in the ſixth Chapter of the ſecond Book) And we will reſolve it alſo by the Artificial *Sines* and *Tangents* on the *Ruler*, and the Tables of *Logarithms*.

But know this, never any ſteer'd at Sea, nearer than to half a Point; and that there are no Halfs nor Quarters marked on the *Compaſs Chart*.

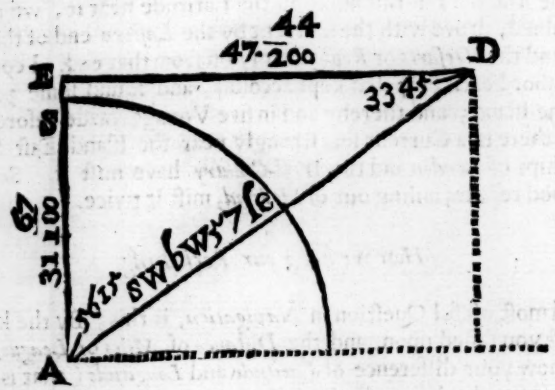
The Firſt Propoſition.

Queſtions of *SAILING* by the Plain *Sea-Chart*.

I. *Sailing* 57 Leagues *upon the fifth* Rhomb, *How much ſhall I alter my* Parallel *of* Latitude?

THE *Angle* that any *Point* makes with the *Meridian*, we call the *Rhomb*; but the *Angle* that it makes with any *Parallel*, is called the *Complement* of the *Rhomb*. Unto every *Point* of the *Compaſs* there anſwers 11 deg. 15 min. therefore the fifth *Rhomb* from the *Meridian* makes *Angles* therewith of 56 deg. 15 min. namely, *S. W. by W. S. E. by E. N. W. by W. N. E. by E.* whoſe *Complement*, 33 deg. 45 min. is the *Angle* of the ſame *Rhomb* with every *Parallel*.

Now admit I ſail from A *to* D, *S. W. by W.* 57 *Leagues, I demand the difference of* Latitude E A.



Firſt, by the following *Traverſe-Table*, at the Head of the *Table*, over every *Column*, is put the *Figure* of the Halfs, Quarters, and the Points of the *Compaſs*, and in one of the *Columns* over head is N. S. and at the Foot E. W. and ſo is numbred at the Head, from the left hand to the right. N. S. ſtands for *Northing*. Then the *Rhombs* are reckoned at the bottom, from the right hand back again; The Margent of the *Tables* ſhew the *Leagues* Sailed; and over *E. W.* or under *E. W.* ſhews how much you have Sailed Eaſt or Weſt from the *Meridian*. N. S. ſhews North or South from the *Latitude* you came from.

As in this Example.

The *Diſtance* ſailed is 57 *Leagues* on the fifth *Rhomb*; therefore againſt *Diſtance* Sailed, in the Side 57 *Leagues*, and in the Common *Angle* or *Line* of *Meeting*, I find 31 67 over N. S. in the Foot; and in the next *Column*, over *E. W.* is 47.39, as you ſee in the *Table*: So that the *Difference* of *Latitude* is 31 *Leagues* and $\frac{67}{100}$ Parts of of a *League*. And if it were required to find the *Departure*, you ſee it to be 47 *Leagues* and $\frac{32}{100}$ *Parts*. This is very plain and eaſie, you need no farther *Precept*.

By the Traverſe-Scale.

EXtend the *Compaſſes* in the *Line* of *Numbers*, from the end of the *Line* marked *North South* 57, the ſame *Diſtance* will reach from 5 Points to 31, and about $\frac{7}{10}$ in the *Line* of *Numbers*.

By

By the Artificial Sines *and* Numbers *on the* Ruler.

EXtend the *Compaſſes* from *Sine* 90 *deg.* to 57 on the *Line* of Numbers; the ſame Diſtance will reach from the *Sine Complement* of the *Rhomb*, to the *Difference* of *Latitude*.

By the Tables *of* Artificial Sines *and* Numbers *by the* Fourth Caſe *of* Plain Right-angled Triangles.

As the *Radius*, or the *Sine* of 90 deg. —— 10000000

Is to the *Diſtance* run 57 Leagues AD —— 1755875
So is the *Sine-Compl.* of the *Rhomb* at the *Angle* D. 33 deg. 45 m. 9744739

To the *Difference* of *Latitude* required AE 31 *Leag.* $\frac{7}{10}$ —— 1500614

In like manner you may find the *Difference* of *Latitude* for any *Diſtance* run upon any Point of the *Compaſs*.

II. *Sailing* 57 Leagues *upon the firſt* Rhomb, *How far am I departed from the* Meridian *of the Place from whence I came?*

By the Traverſe-Table.

THis *Queſtion* was anſwered in the laſt *Example*, and found over *E. W.* to be 47 *Leagues* and $\frac{39}{100}$. In like manner you may find the *Difference* of *Latitude* and departure from the *Meridian*, for any *Diſtance* run upon any Point of the *Compaſs*, which is the Uſe of that *Table*.

By the Traverſe-Scale.

EXtend the *Compaſſes* from the end of the *Line* marked *Eaſt*, *Weſt*, to the *Diſtance* run 57 *Leagues*, then put one Point of the *Compaſs* on 5 Points, in the *Line* of *Eaſt* and *Weſt* of the *Scale*, and the other will reach to the *Departure* from the *Meridian* 47 *Leagues* $\frac{47}{100}$ *Parts*.

By the Tables *of* Sines *and* Numbers, *by the* Third Caſe *of* Plain Right-angled Triangles.

As the *Radius* or *Sine* of 90 deg. —— 10000000

Is to the *Diſtance* run, 57 *Leagues* AD —— 1755875
So is the *Sine* of the *Rhomb* 56 *deg.* 15 *min.* the *Angle* at A —— 9919846

To the *Departure* from the *Meridian* to 47 $\frac{39}{100}$ ED —— 1675721

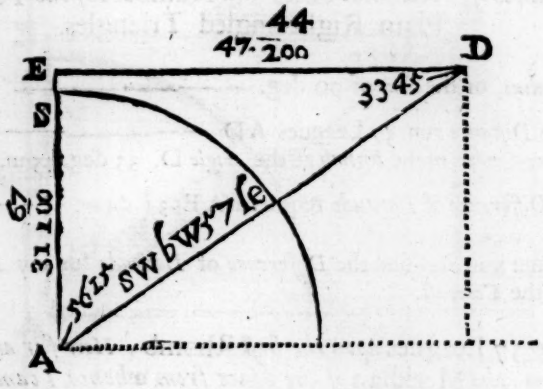
By the Artificial Lines *on the* Ruler.

EXtend the *Compaſſes* from 90 *deg.* to 57; the ſame *Diſtance* will reach from the *Sine* 56 *deg.* 15 *min.* to 47 $\frac{47}{100}$ *Leagues*.

Or, Extend the *Compaſſes* from *Sine* 90, to *Sine* 56 *deg.* 15 *min.* the ſame *Diſtance* will reach from 57 *Leagues*, to 47 $\frac{47}{100}$, as before.

III. *Sailing upon the fifth* Rhomb, *until I alter my* Latitude 31 $\frac{67}{100}$ Leagues. *I demand how far I have Sailed?*

AS Sailing from A to D, *S. W. b. W.* till the *Difference* of *Latitude* be 31 *Leag.* $\frac{67}{100}$ I demand the *Diſtance* run A D.



Firſt, By the *Traverſe-Table*, Look in the Foot of the *Table* for the fifth *Rhomb*, and over *N. S.* in that *Column*, look for 31 *Leagues* $\frac{67}{100}$, and in the *Common Angle* of *Meeting*, to the left hand, under *Diſtance Sailed*, you will find *Diſtance Sailed* 57 *Leagues* required.

By the Line *of* Sines *and* Numbers.

EXtend the *Compaſſes* from the *Complement-Sine* 33 *deg.* 45, to 31 $\frac{67}{100}$ the *Difference* of *Latitude*; the ſame Extent will reach from *Sine* 90 *deg.* to 57 *Leagues*.

Or, Extend the *Compaſſes* from *Sine* 33 *deg.* 45 *min.* to *Sine* 90; the ſame *Diſtance* will reach from 31 $\frac{67}{100}$ *Leagues*, to 57 *Leagues*, the *Diſtance* A D, as before.

By the Logarithms.

Say by the ſecond *Caſe* in *Plain Right-angled Triangles*.

As the *Sine Compl.* of the *Rhomb*, 33 deg. 45 —— 9,744739

Is to the *Difference* of *Latitude* 31 $\frac{67}{100}$ *Leagues* —— 1500648

So is the *Sine* of 90 deg. or *Radius* —— 10000000

To the *Diſtance* run A D 57 Leagues —— 1755909

IV. *Sailing upon the fifth* Rhomb, *until I have altered my* Latitude 31 $\frac{67}{100}$ *or* 1 deg. 35 min. *How much am I departed from my firſt* Meridian?

AS ſailing from A to D, *S. W. b. W.* till the *Difference* of *Latitude* A E be 31 $\frac{67}{100}$ *Leagues*, I require B C my departure from my *Meridian*.

By the Traverſe-Table.

AS in the laſt *Caſe*, find 31 $\frac{67}{100}$ *Leagues* over the fifth *Rhomb*, and in the next *Column* to the left hand, over *E. W.* is 47 $\frac{19}{100}$ *Leagues*, the *Departure* required.

By

By the Line *of* Sines *and* Numbers.

EXtend the *Compaſſes* from the *Complement Sine* of the *Rhomb*, to 33 deg. 45, to 31 $\frac{67}{100}$ the *Leagues*; the ſame Diſtance will reach from *Sine* 56 deg. 15 min. the *Rhomb*, to 47 $\frac{47}{100}$ *Leagues*, the Departure from the *Meridian*.

By the firſt Caſe *of* Plain Right-angled Triangles.

As *Radius*	10000000
To the *difference* of *Latitude* AE 31 $\frac{67}{100}$	1500648
So is the *Tangent* of the *Rhomb* 56 deg. 15	10175107
To the *departure* from the *Meridian* 47 $\frac{39}{100}$ *Leagues.*	1,675755

V. *Sailing upon ſome* Rhomb *between the* South *and the* Weſt 57 Leagues *and finding I have altered my* Latitude 31 $\frac{67}{100}$ Leagues, *I demand upon what* Point *I have ſailed.*

SUppoſe I had ſailed from A to D (being a *Rhomb* between the *Weſt* and *South*) 57 *Leagues*, and then find the *difference* of *Latitude* 31 $\frac{67}{100}$ *Leagues*, I demand the *Angle* DAE.

By the Traverſe-Table.

AGainſt 57 Leagues the Column of Diſtance Sailed, and in that *Line* or Common *Angle* of Meeting, you muſt find the *difference* of *Latitude* 31 $\frac{67}{100}$ *Leagues*, which will be over the fifth *Rhomb*, which was required.

By the Line *of* Sines *and* Numbers *on the* Scale.

EXtend the *Compaſſes* from the Diſtance run 57 *Leagues*, to the *Sine* of 90; the ſame Diſtance will reach from the Difference of *Latitude*, to the *Sine-Compl.* of the *Rhomb*. 33 deg. 45 min.

Or, open the *Compaſſes* from 57 *Leagues* the Diſtance, to 31 $\frac{67}{100}$ the Difference of Latitude; the ſame Diſtance will reach from the *Sine* of 90, to the *Sine* of 33 deg. 45 min. the *Compl. Rhomb*.

By the Logarithms.

As the Diſtance on the *Rhomb* AC 57 Leagues	1755875
Is to the Difference of *Latitude* 31 $\frac{67}{100}$ Leagues AB	1500648
So is the *Sine* of 90 deg.	10000000
To the *Sine Compl.* of the Rhomb 33 deg. 45 m. the Sum-	11500648
The firſt Number ſubtract	1755875
The *Sine* of the *Angle* ADE	9,744873

The *Sine Compl.* of the *Rhomb* 33 deg. 45, ſubtracted from 90 deg. there remaines the *Angle* of the *Rhomb* 56 deg. 15 min. which is five Points, namely *S. W. b. W.*

VI. *Sail-*

VI. *Sailing upon ſome* Rhomb *between the* South *and the* Weſt 57 Leagues, *and finding I have altered my* Latitude 31 $\frac{67}{100}$ Leagues, *I demand my Departure from my firſt* Meridian.

By the Traverſe-Table.

AGainſt 57 *Leagues* in the Column of Diſtance Sailed, and in that *Line* or *Angle* of Meeting: find 31 $\frac{67}{100}$ *Leagues*, and in the Column to the left hand you will have 47 $\frac{39}{100}$ the departure from the *Meridian*.

Diſtance run A C 57 Leagues } Sum 88 $\frac{67}{100}$ Leagues ——	1,947777
Diff. of Lat. A B 31 $\frac{67}{100}$ Leagues } Remain 25 $\frac{33}{100}$ Leag. ——	1,403635
	3,351412
Departure from the Meridian B C 47 $\frac{39}{100}$ Leagues ——	1,675706

Which is thus done. To the Diſtance run, add the Difference of *Latitude*, and alſo ſubtract it from the ſame, noting the *Sum* and *Remainder*; then add together the *Logarithms* of this *Sum* and *Remain*, and half that *Sum* is the *Logarithm* of the Departure from the firſt *Meridian*.

CHAP. II.

What muſt be obſerved by all that keep Account *of a* Ship's Way *at* Sea; *And to find the true* Point *of the* Ship *at any time, according to the* Plain Chart.

I Might have further inlarged and multiplyed *Queſtions*, but that I think theſe ſufficient for any uſe at preſent; and therefore I will be brief, and come to the moſt material Buſineſs, (*viz.*)

The whole Practice of the *Art* of *Navigation*, in keeping of a right *Reckoning*, conſiſts chiefly of three *Members* or *Branches*.

Firſt, In a well experienced Judgment, in eſtimating the *Ship's Way* or *Diſtance* Sailed upon every ſhift of Wind.

Secondly, In duly eſtimating the *Courſe* or *Point* of the *Compaſs* on which the *Ship* hath made her way good; allowing for *Lee-way Currents*, and the *Variation* of the *Compaſs*.

Thirdly, The diligent taking all Opportunities of due obſerving of the *Latitude*.

The *Reckoning* ariſing out of the two firſt *Branches*, we call our *Dead Reckoning*; and of theſe three *Branches* there ought to be ſuch an Harmony and Agreement, that any two being given, a third may be found with Truth.

As, Having the *Courſe* and *Diſtance*, to find the *Latitude* of the *Ship's Place*.

Or, By the *Courſe* and *Difference* of *Latitude*, to find the *Diſtance*:

Or, By the *Difference* of *Latitude* and *Diſtance* to find the *Courſe*.

But in the midſt of ſo many uncertainties that daily occur in the Practice of *Navigation*, a joynt Conſent in theſe three *Particulars*, is hardly to be expected; and when an Error ariſeth, the ſole Remedy to be truſted to, is the Obſervation of the *Latitude*, and how to rectifie the *Reckoning* by the obſerved *Latitude*, we ſhall ſhew hereafter.

THE

THE LOG-BOARD

S. S.

1666.

Hours.	*Course.*	*Knots*	*Half Knots*	*Fath.*	*Wind.*
2	S. E. b. S.	7	½	2	N.
4	S. S. W.	6	½		
6	E. b. N.	9			N.b.W.
8	N. b. E. ½ E.	8			N. W.
10	N. N. W. ½ W.	7	½		E. N. E.
12	W. N. W.	9			N. E.
2	S. E. by S.	8	½	2	
4	S. S. W.	7	½		E.
6	S. W. b. S.	6			E.S.E.
8	S. W.	9			S. E.
10	S. W.	8	½	3	S. E. b. E.
12	S. E.	9			S.W.b.W.

But first of all it is most necessary to shew how we do keep our reckoning at *Sea*, by the *Log-Board*, and take an account in our *Journal*.

In the *Log-Beard*, The first *Column* is for *Time*.
The second for the *Ships Course*.
The third for the *Knots*.
The fourth for the *Half Knots*.
The fifth for the *Fathoms*.
The sixth is to put down the *Wind*, and thereby to give allowance to your *Course*, according to the *Lee-way* you have made by taking in or having out more Sail.

The *Italian Mile* by which we reckon at *Sea*, contains 1000 *Paces*, and each *Pace* 5 *Foot*, and every *Foot* 12 *Inches*; the 120 part of that *Mile* is 41 ⅔ *Feet*, and so much is the space between the *Knots* upon the *Log-line*: so many *Knots* as the Ship runs in half a *Minute*, so many *Miles* she Saileth in an *Hour*; or so many *Leagues* and so many *Miles* she runneth in a *Watch*, which is four *Hours*, the time in which half the *Company* belonging to the *Ship* watch by turns

EXAMPLE.

Nine *Knots* in half a *Minute*, is nine *Miles* in an *Hour*, which is nine *Leagues* and nine *Miles* in a *Watch*, that is 12 *Leagues* or 36 *Miles* every *Noon*, after the Master and Mates have observed the *Sun*'s *Altitude*, (if fair weather) they take the *Reckoning* from the *Log-beard*, and double the *Knots* run, which is the number of *Miles* run upon any *Course*.

We

We throw the *Log* every two *Hours*, and we never expreſs the *Courſe* ſteered nearer than half a *Point* of the *Compaſs*.

Mr. *Norwood* gives full ſatisfaction in his *Seaman's Practice*, by his own *Experience*, That in our ordinary Practice at *Sea*, we cannot, if we will yeild Truth the Conqueſt, allow leſs than 360000 of our *Engliſh Feet* to vary one *Degree* of *Latitude* in ſailing North or South under any *Meridian*. According to this Meaſure, there will be in a *Degree* 68 $\frac{2}{11}$ of *Miles* of our *Statute-Meaſure*, each *Mile* 5280 *Feet*, and by the common *Sea-meaſure* 5000 *Feet* to a *Mile*, there will be 72 *Miles*, or 24 *Leagues* in a *Degree*, which we will take for truth.

Now if you would have ſhewn the *Miles* of a *Degree*, allowing 60 to a *Degree*, the *Miles* muſt be enlarged proportionably, and the diſtance between every one of the *Knots* muſt be 50 *Foot*, and as many of theſe as run out in half a *Minute*, ſo many *Miles* or *Minutes* the *Ship* ſaileth in an *Hour*; and for every 5 *Foot* more, you muſt allow the 10*th* part of a *Mile*.

Sailing between any two Places, and uſing a *Log-line* that hath a *Knot* at every 7 *Fathoms*, and to reduce it into ſuch Miles 60 to a Degree, each containing 6000 *Feet*, the *Proportion* in *Number* of theſe two is this, *As* 6 *to* 5; for 6 *Knots* of 6 *Fathoms* $\frac{2}{3}$, makes 5 of 8 $\frac{2}{3}$ *Fathom*, or 50 *Feet*. Admit a Man keeps a Reckoning of his Ship by a *Log-line* of 6 *Fathom* $\frac{2}{3}$ and by it find the diſtance of two Places 1524 *Miles*, or 508 *Leagues*, and would know the diſtance by a *Log-line* of 50 *Feet* to a *Knot*, or 6000 *Feet* to a *Mile*.

Say then by the *Rule* of *Proportion*, *As* 6 *is to* 5 : *So is* 1524 *to* 1270 *Miles*.

Next we will work the *Courſes* of the *Log-board*, and by it find the difference of *Latitude*, and departure from the firſt *Meridian*.

A Ship being in the *Latitude* of 47 deg. 30 min. North, and *Longitude* 00 deg. the *Courſes* of the *Log-board* are S.E.b.S. 16 Miles, and S.S.W. 13 Miles, E. b. N. 18 Miles and N. b. E. $\frac{1}{2}$ E. 16 Miles, N. N. W. $\frac{1}{2}$ W. 15 Miles, and W. N.W. 18 Miles, and S.E. b.S. 18 Miles, and S. S. W. 15 Miles, S. W. by, S. 12 Miles, and S.W. 18 Miles, S. E. 18. Miles by the *Wind*, which are W. S. W. and E. S. E. The Ship made 14 Points and a half *Lee-way* on the two laſt *Courſes*.

To find the difference of Latitude *and* Departure *from the* Meridian *this* 24 *Hours*.

There are ſeveral ways to work *Traverſes*; but the readieſt is by the *Traverſe-Scale*, or the following *Table*; We ſhall work the former *Traverſe* by the *Tables* following, and you at leiſure way work it by the *Traverſe-Scale*, and find the near agreement of both.

Course by Compass.	*Miles sailed.*	North. *Miles.*	North. *Parts.*	South. *Miles.*	South. *Parts.*	East. *Miles.*	East. *Parts.*	West. *Miles.*	West. *Parts.*
S. E. b. S.	16			13	30	38	89		
S. S. W.	13			12	01			04	97
E. b. N.	18	03	51			17	65		
N. b. E. $\frac{1}{2}$ E.	16	15	31			04	64		
N. N. W. $\frac{1}{2}$ W.	15	12	23					07	07
W. N. W.	18	06	89					16	63
S. E. by S.	18			14	97	10	00		
S. S. W.	15			13	86			05	74
S. W. b. S.	12			09	98			06	67
W. S. W.	18			06	89			16	63
E. S. E.	18			06	89	16	63		
Sum		38	94	77	90	57	81	57	71
Substract least				38	94	57	71		
Remains diff. Latitude.				38	96	00	10	*Depart.*	

The Latitude *the* Ship *is in is* 46 deg. 51 min.

You must put down the *Courses* made good upon each *Point* of the *Compass*, and Number of Miles you find sailed on them by the *Log-Board*; And make 4 other *Columns* and mark them with North, South, East, West, in such manner as I have done in this *Table*: Then according to the *Rhombs* look in the *Table* following for the *Point*, *Half*, or *Quarter* Sailed, and the Distance in *Miles* or *Leagues* in the right-hand or left-hand *Column*, and put down the Difference of *Latitude* and *Departure* under the North or South, East or West Columns, according to the following Directions.

As for Example.

The first *Course* sailed is three *Points* from the *Meridian*; namely, S. E. b. S. under that *Column* I count 16 Miles in the side, and find against it 13 $\frac{18}{100}$ Miles Southing, and 8 $\frac{12}{100}$ Miles Easting, because the *Course* is South Easterly. I put it down in the *Table* in its place, 13. 30 under South, 8. 89 under East. In the like manner you must do by the rest. Likewise the last *Course* is E. S. E. that is 6 from the *South*; therefore I reckon them in the foot of the *Table*, and right against 18 I find 06. 89 *Southward*, and 16. 63 Eastward; which you may put down as I have done in the *Table*. In like manner you must do if your *Course* were *North-Westing*. This is so plain it needs no farther *Precept*.

Then add up the *Sums* in the North, South, East and West Columns, and substract the lesser out of the greater, the Remainer is the Difference of *Latitude* and *Departure*: As I find that the *Ship* hath gone but 38 $\frac{96}{100}$ Miles to the Southward, and the *Latitude* she now is in is 46 deg. 51 min. and the Eastward but $\frac{10}{100}$ parts of a Mile: Therefore her *Course* is near South.

CHAP. III.

A Formal and Exact Way of Setting down and Perfecting a Sea-Reckoning.

The Rule of keeping a perfect Sea-Reckoning, *is beſt ſet down in particular after the general true* Sea-Chart, in Chap. 17. *of* Great-Circle-Sailing.

THis being the moſt neceſſary Rule in this *Art* of *Navigation*, How to keep an exact *Reckoning*; Although the *Courſe* and *Diſtance* cannot be ſo truly and certainly known as the *Latitude* may be; yet we muſt endeavour in theſe alſo to come as near the truth as may be; the rather, for that ſome *Reckonings* muſt neceſſarily depend wholly upon them. Therefore we come now to ſhew an Orderly and Exact way of Framing and Keeping a *Reckoning* at *Sea*; for which purpoſe I have inſerted this *Table* following, which ſheweth how much a Ship is more Northerly or Southerly, and how much Eaſterly or Weſterly, by ſailing upon any *Point* or *Quarter-point* of the *Compaſs*, any diſtance or number of *Miles* or *Leagues* propoſed.

Note,

If the *Diſtance* Sailed exceed 100 Miles or Leagues, you muſt enter the *Table* twice or oftner; as in the following *Example*.

Suppoſe a Ship ſails away South, half a *Point* Weſterly 173 *Leagues* or *Miles*; we ſet down this Number thus.

Courſe	*Diſtance.*	*Southing.*	*Weſting*
South	100	9951	980
½ *Point* W.	70	6966	686
	3	298	29
Leagues.	173	17215	1695

Look into the firſt *Column* for the half *Point*, and then in the third *Column* you may ſee 980; alſo againſt 70, there is 6966, and in the ſecond 686; and in the third againſt three in the firſt *Column* is 298, in the ſecond is $\frac{22}{100}$.

Theſe ſummed up as in the *Table*, ſhews that the Ship ſailing upon the firſt half *Point* from the *Meridian*, namely, S. ½ W. is to the Southwards of the Place ſhe departed 172 $\frac{15}{100}$ *Leagues* or *Miles*, and to the *Weſtward* 16 *Leagues* and $\frac{21}{100}$.

A Traverse-Table *for every* Point, Half-Point, *and* Quarter-Point *of the* Compass, *to the* 100 *part of a* League *or* Mile; *which gives the* Diff. *of* Lat. *and* Depar. *from the* Meridian.

Diff. in Leag. or Miles sail'd.	2 deg. 49 m. — 0 Point ¼				5 deg. 37 m. — 0 Point ½				8 deg. 26 m. — 0 Point ¾				11 deg. 15 m. — 1 Point.				Diff. in Leag. or Miles sail'd.
	N	S	E	W	N	S	E	W	N	S	E	W	N	S	E	W	
1	01	00	00	05	01	00	00	10	00	98	00	14	00	98	00	20	1
2	02	00	00	10	01	99	00	20	01	97	00	29	01	96	00	39	2
3	03	00	00	15	02	98	00	29	02	96	00	44	02	94	00	58	3
4	04	00	00	20	03	98	00	39	03	95	00	58	03	92	00	78	4
5	04	09	00	25	04	97	00	49	04	94	00	73	04	90	00	98	5
6	05	09	00	29	05	97	00	59	05	93	00	88	05	88	01	17	6
7	06	09	00	34	06	97	00	69	06	92	01	02	06	86	01	37	7
8	07	09	00	39	07	96	00	78	07	91	01	17	07	85	01	56	8
9	08	09	00	44	08	96	00	88	08	90	01	32	08	83	01	76	9
10	09	09	00	49	09	95	00	98	09	89	01	46	09	81	01	95	10
11	10	98	00	54	10	95	01	08	10	88	01	61	10	79	02	15	11
12	11	98	00	59	11	94	01	18	11	87	01	76	11	77	02	34	12
13	12	98	00	63	12	94	01	27	12	86	01	91	12	75	02	54	13
14	13	98	00	68	13	93	01	37	13	85	02	05	13	73	02	73	14
15	14	98	00	73	14	93	01	47	14	84	02	20	14	71	02	19	15
16	15	98	00	78	15	92	01	57	15	83	02	34	15	69	03	12	16
17	16	98	00	83	16	92	01	67	16	82	02	49	16	67	03	32	17
18	17	97	00	88	17	91	01	76	17	80	02	64	17	65	03	51	18
19	18	97	00	93	18	91	01	86	18	79	02	79	18	64	03	71	19
20	19	97	00	98	19	90	01	96	19	78	02	93	19	62	03	90	20
21	20	97	01	03	20	90	02	06	20	77	03	08	20	60	04	10	21
22	21	97	01	08	21	98	02	16	21	76	03	22	21	58	04	29	22
23	22	97	01	13	22	98	02	25	22	75	03	37	22	56	04	49	23
24	23	97	01	17	23	88	02	35	23	74	03	52	23	54	04	68	24
25	24	97	01	22	24	88	02	45	24	73	03	66	24	52	04	88	25
26	25	96	01	27	25	87	02	55	25	71	03	81	25	50	05	07	26
27	26	96	01	32	26	87	02	65	26	70	03	96	26	48	05	27	27
28	27	96	01	32	27	86	02	75	27	69	04	10	27	46	05	46	28
29	28	96	01	42	28	86	02	84	28	68	04	25	28	44	05	66	29
30	29	96	01	47	29	86	02	94	29	67	04	40	29	42	05	85	30
31	30	96	01	52	30	85	03	04	30	66	04	55	30	40	06	05	31
32	31	96	01	57	31	85	03	14	31	65	04	69	31	38	06	24	32
33	32	96	01	61	32	84	03	23	32	64	04	84	32	37	06	44	33
34	33	95	01	66	33	84	03	33	33	63	04	98	33	35	06	63	34
35	34	95	01	71	34	83	03	43	34	62	05	13	34	33	06	83	35
36	35	95	01	75	35	83	03	53	35	61	05	28	35	31	07	02	36
37	36	95	01	81	36	82	03	63	36	60	05	42	36	29	07	22	37
38	37	95	01	86	37	82	03	73	37	59	05	57	37	27	07	41	38
39	38	95	01	91	38	81	03	82	38	58	05	72	38	25	07	61	39
40	39	95	01	96	39	81	03	92	39	57	05	87	39	23	07	80	40
41	40	95	02	01	40	80	04	02	40	55	06	02	40	21	08	00	41
42	41	95	02	06	41	80	04	12	41	54	06	16	41	19	08	19	42
43	42	95	02	11	42	79	04	21	42	53	06	31	42	17	08	39	43
44	43	94	02	15	43	79	04	31	43	52	06	45	43	15	08	58	44
45	44	94	02	20	44	78	04	41	44	51	06	60	44	14	08	78	45
46	45	94	02	25	45	78	04	51	45	60	06	75	45	12	08	77	46
47	46	94	02	30	46	77	04	61	46	49	06	89	46	10	09	17	47
48	47	94	02	35	47	77	04	70	47	48	07	04	47	08	09	36	48
49	48	94	02	40	48	76	04	80	48	47	07	20	48	06	09	56	49
50	49	94	02	45	49	76	04	90	49	46	07	33	49	04	09	75	50
51	50	93	02	50	50	75	05	00	50	44	07	48	50	02	09	95	51
52	51	93	02	55	51	75	05	10	51	43	07	63	51	00	10	14	52
53	52	93	02	60	52	74	05	20	52	42	07	77	51	98	10	34	53
54	53	93	02	65	53	74	05	29	53	41	07	92	52	96	10	53	54
55	54	93	02	70	54	73	05	39	54	40	08	07	53	94	10	73	55
56	55	93	02	75	55	73	05	49	55	30	08	21	54	92	10	92	56
57	56	93	02	79	56	72	05	59	56	38	08	36	55	90	11	12	57
58	57	93	02	84	57	72	05	68	57	37	08	51	56	89	11	31	58
59	58	92	02	89	58	71	05	78	58	36	08	65	57	87	11	51	59
60	59	92	02	94	59	71	05	88	59	35	08	80	58	85	11	70	60
70	69	91	03	43	69	66	06	86	69	24	10	27	68	65	13	65	70
80	79	90	03	92	79	61	07	84	79	13	11	73	78	46	15	60	80
90	89	89	04	41	89	56	08	82	89	02	13	20	88	27	17	55	90
100	99	87	04	90	99	51	09	80	98	91	14	67	98	08	19	50	100
200	199	76	09	80	199	02	19	90	197	82	29	34	196	16	39	00	200
	E	W	N	S	E	W	N	S	E	W	N	S	E	W	N	S	
	7 Point ¾				7 Point ½				7 Point ¼				7 Point.				
	87 deg. 11 m				84 deg. 22 m.				81 deg. 34 m.				78 deg. 45 m.				

A Traverse-Table *for every* Point, Half-Point, *and* Quarter-Point *of the* Compass, *to the* 100 *part of a* League *or* Mile; *which gives the* Diff. *of* Lat. *and* Depar. *from the* Meridian.

Diff. in Legg. or Miles sail'd	14 deg. 04 m. — 1 Point ¼				16 deg. 52 m. — 1 Point ½				19 deg. 41 m. — 1 Point ¾				22 deg. 30 m. — 2 Points.				Diff. in Legg. or Miles sail'd
	N	S	E	W	N	S	E	W	N	S	E	W	N	S	E	W	
1	00	97	00	24	00	96	00	29	00	94	00	33	00	92	00	38	1
2	01	94	00	48	01	91	00	58	01	88	00	67	01	85	00	76	2
3	02	91	00	72	02	87	00	87	02	82	01	01	02	77	01	75	3
4	03	88	00	97	03	83	01	16	03	77	01	34	03	70	01	53	4
5	04	85	01	21	04	78	01	45	04	71	01	68	04	62	01	91	5
6	05	82	01	45	05	74	01	74	05	65	02	02	05	54	02	30	6
7	06	79	01	70	06	70	02	03	06	59	02	35	06	47	02	68	7
8	07	76	01	94	07	66	02	32	07	53	02	70	07	39	03	16	8
9	08	73	02	18	08	61	02	61	08	47	03	03	08	31	03	44	9
10	09	70	02	43	09	57	02	90	09	41	03	37	09	24	03	83	10
11	10	67	02	67	10	53	03	19	10	36	03	71	10	16	04	21	11
12	11	64	02	91	11	48	03	48	11	30	04	04	11	09	04	59	12
13	12	61	03	15	12	44	03	77	12	24	04	36	12	01	04	97	13
14	13	58	03	40	13	40	04	06	13	18	04	72	12	93	05	36	14
15	14	55	03	64	14	35	04	35	14	12	05	05	13	86	05	74	15
16	15	52	03	88	15	31	04	64	15	06	05	39	14	78	06	12	16
17	16	49	04	13	16	27	04	93	16	00	05	73	15	71	06	51	17
18	17	46	04	37	17	22	05	22	16	95	06	06	16	63	06	89	18
19	18	43	04	61	18	18	05	51	17	89	06	40	17	55	07	27	19
20	19	40	04	86	19	14	05	81	18	83	06	74	18	48	07	65	20
21	20	37	05	10	20	10	06	10	19	77	07	08	19	40	08	04	21
22	21	34	05	34	21	05	06	39	20	71	07	41	20	32	08	42	22
23	22	34	05	48	22	01	06	68	21	66	07	75	21	25	08	80	23
24	23	28	05	83	22	97	06	97	22	60	08	08	22	17	09	18	24
25	24	25	06	07	23	91	07	26	23	54	08	42	23	10	09	57	25
26	25	22	06	31	24	88	07	55	24	48	08	76	24	02	09	95	26
27	26	19	06	56	25	84	07	84	25	42	09	10	24	94	10	33	27
28	27	16	06	80	26	79	08	13	26	36	09	43	25	87	10	71	28
29	28	13	07	04	27	75	08	42	27	30	09	77	26	79	11	10	29
30	29	10	07	28	28	71	08	71	28	25	10	11	27	72	11	48	30
31	30	07	07	53	29	66	09	00	29	19	10	44	28	64	11	86	31
32	31	04	07	77	30	62	09	29	30	13	10	74	29	56	12	25	32
33	32	01	08	01	31	58	09	58	31	07	11	12	30	49	12	63	33
34	32	98	08	26	32	54	09	87	32	01	11	45	31	44	13	01	34
35	33	95	08	50	33	49	10	16	32	95	11	79	32	34	13	39	35
36	34	92	08	74	34	45	10	45	33	89	12	13	33	26	13	78	36
37	35	89	08	99	35	41	10	74	34	84	12	47	34	18	14	16	37
38	36	86	09	23	36	36	11	03	35	78	12	80	35	11	14	54	38
39	37	83	09	47	37	32	11	32	36	72	13	14	36	03	14	92	39
40	38	80	09	71	38	28	11	61	37	66	13	48	36	96	15	31	40
41	39	77	09	96	39	23	11	90	38	60	13	81	37	88	15	69	41
42	40	74	10	20	40	19	12	19	39	34	14	15	38	80	16	07	42
43	41	71	10	44	41	15	12	48	40	49	14	49	39	73	16	45	43
44	42	68	10	69	42	12	12	77	41	43	14	72	40	65	16	84	44
45	43	65	10	63	43	06	13	06	42	37	15	16	41	57	17	22	45
46	44	62	11	17	44	62	13	35	43	41	15	50	42	50	17	60	46
47	45	59	11	42	44	98	13	64	44	25	15	83	43	42	17	99	47
48	46	56	11	66	45	95	13	93	45	19	16	17	44	35	18	37	48
49	47	33	11	90	46	89	14	22	46	13	16	37	45	27	18	75	49
50	48	50	12	14	47	85	14	51	47	08	16	85	46	19	19	13	50
51	49	47	12	39	48	80	14	80	48	01	17	18	47	12	19	52	51
52	50	44	12	63	49	76	15	09	48	96	17	31	48	04	19	89	52
53	51	41	12	87	50	72	15	38	49	90	17	85	48	97	20	28	53
54	52	38	13	12	51	67	15	67	50	84	18	19	49	89	20	66	54
55	53	35	13	36	52	63	15	96	51	78	18	53	58	01			55
56	54	32	13	60	53	59	16	26	52	73	18	87	51	73	21	15	56
57	55	29	13	85	54	55	16	55	53	67	19	20	52	66	21	43	57
58	56	26	14	09	55	50	16	84	54	61	19	54	53	58	22	81	58
59	57	23	14	33	56	46	17	23	55	55	19	87	54	21	22	20	59
60	58	20	14	57	57	42	17	42	56	49	20	21	55	43	22	58	60
70	67	90	17	00	66	90	20	31	65	90	23	58	64	67	26	78	70
80	77	60	19	43	76	55	23	22	75	32	26	95	73	91	30	61	80
90	87	30	21	86	86	10	26	12	84	73	30	39	83	14	34	44	90
100	97	00	24	29	95	69	29	02	94	15	33	68	92	38	38	26	100
200	194	00	48	58	191	38	58	04	188	30	67	36	184	76	36	52	200
	E	W	N	S	E	W	N	S	E	W	N	S	E	W	N	S	
	6 Points ¼				6 Points ½				6 Points ¼				6 Points.				
	75 deg. 56 m.				73 deg. 07 m.				70 deg. 19 m.				67 deg. 30 m.				

A Traverse-Table *for every* Point, Half-Point, *and* Quarter-Point *of the* Compass, *to the* 100 *part of a* League *or* Mile; *which gives the* Diff. *of* Lat. *and* Depar. *from the* Meridian.

Dif. in Leag. or Miles	25 deg. 19 m. 2 Points ¼				28 deg. 07 m. 2 Points ½				30 deg. 56 m. 2 Points ¼				33 deg. 45 m. 3 Points.				Dif. in Leag. or Miles
	N	S	E	W	N	S	E	W	N	S	E	W	N	S	E	W	
1	00	90	00	43	00	88	00	47	00	86	00	51	00	83	00	56	1
2	01	81	00	85	01	76	00	94	01	71	01	03	01	66	01	55	2
3	02	71	01	28	02	65	01	41	02	57	01	54	02	49	01	67	3
4	03	61	01	71	03	53	01	89	03	43	02	06	03	32	02	22	4
5	04	52	02	14	04	41	02	36	04	29	02	57	04	16	02	78	5
6	05	42	02	56	05	29	02	83	05	15	03	08	04	99	03	33	6
7	06	33	02	99	06	17	03	30	06	00	03	60	05	82	03	89	7
8	07	23	03	42	07	05	03	77	06	86	04	11	06	65	04	44	8
9	08	14	03	85	07	94	04	24	07	72	04	63	07	48	05	00	9
10	09	04	04	28	08	82	04	71	08	58	05	14	08	31	05	55	10
11	09	94	04	70	09	70	05	18	09	44	05	66	09	15	06	11	11
12	10	85	05	13	10	58	05	66	10	29	06	17	09	98	06	67	12
13	11	75	05	56	11	46	06	13	11	15	06	68	10	81	07	22	13
14	12	66	05	99	12	35	06	60	12	00	07	20	11	64	07	78	14
15	13	56	06	41	13	23	07	07	12	87	07	71	12	47	08	33	15
16	14	46	06	84	14	11	07	54	13	72	08	23	13	30	08	89	16
17	15	37	07	27	14	99	08	01	14	58	08	74	14	13	09	44	17
18	16	27	07	70	15	87	08	48	15	44	09	25	14	97	10	00	18
19	17	18	08	12	16	76	08	96	16	30	09	77	15	80	10	56	19
20	18	08	08	55	17	64	09	43	17	16	10	28	16	63	11	11	20
21	18	98	08	98	18	52	09	90	18	01	10	80	17	46	11	67	21
22	19	89	09	41	19	40	10	37	18	87	11	31	18	29	12	22	22
23	20	79	09	83	20	28	10	84	19	73	11	82	19	12	12	78	23
24	21	60	10	26	21	17	11	31	20	59	12	34	19	95	13	33	24
25	22	60	10	69	22	05	11	78	21	44	12	85	20	79	13	89	25
26	23	50	11	12	22	93	12	26	22	30	13	57	21	62	14	44	26
27	24	41	11	54	23	81	12	73	23	16	13	88	22	45	15	15	27
28	25	31	11	97	24	69	13	20	24	02	14	39	23	28	15	56	28
29	26	22	12	40	25	58	13	67	24	87	14	91	24	11	16	11	29
30	27	12	12	83	26	46	14	14	25	73	15	42	24	94	16	67	30
31	28	02	13	25	27	34	14	61	26	59	15	94	25	78	17	22	31
32	28	93	13	68	28	22	15	08	27	45	16	45	26	61	17	78	32
33	29	83	14	11	29	10	15	56	28	31	16	97	27	44	18	33	33
34	30	74	14	54	29	98	16	03	29	16	17	48	28	27	18	89	34
35	31	64	14	96	30	87	16	50	30	02	17	99	29	10	19	44	35
36	32	54	15	39	31	75	16	97	30	88	18	51	29	93	20	00	36
37	33	45	15	82	32	63	17	44	31	74	19	02	30	76	20	56	37
38	34	35	16	25	33	57	17	91	32	59	19	54	31	60	21	11	38
39	35	26	16	68	34	40	18	38	33	45	20	05	32	43	21	67	39
40	36	16	17	10	35	28	18	86	34	31	20	56	33	26	22	22	40
41	37	06	17	53	36	16	19	34	35	17	21	08	34	09	22	78	41
42	37	67	17	96	37	04	19	81	36	02	21	59	34	92	23	34	42
43	38	87	18	38	37	92	20	27	36	88	22	11	35	75	23	89	43
44	39	78	18	81	38	80	20	74	37	74	22	62	36	58	24	44	44
45	40	68	19	24	39	69	21	21	38	60	23	14	37	42	25	00	45
46	41	51	19	67	40	57	21	68	39	46	23	65	38	25	25	56	46
47	42	49	20	09	41	41	22	16	40	31	24	16	39	08	26	11	47
48	43	39	20	52	42	43	22	63	41	17	24	68	39	91	26	67	48
49	44	30	20	95	43	21	23	10	42	03	25	19	40	74	27	22	49
50	45	20	21	38	44	10	23	57	42	89	25	71	41	57	27	78	50
51	46	10	21	61	44	98	24	04	43	74	26	22	42	40	28	33	51
52	47	01	22	23	45	86	24	51	44	60	26	73	43	24	28	89	52
53	47	91	22	66	46	74	24	98	45	46	27	25	44	07	29	44	53
54	48	82	23	08	47	62	25	46	46	32	27	76	44	90	30	00	54
55	49	72	23	52	48	51	25	93	47	17	28	28	45	73	30	56	55
56	50	62	23	94	49	39	26	40	48	03	28	79	46	56	31	11	56
57	51	53	24	37	50	27	26	87	48	89	29	30	47	39	31	67	57
58	52	43	24	79	51	15	27	34	49	75	29	82	48	22	32	22	58
59	53	33	25	23	52	03	27	81	50	61	30	33	49	06	32	78	59
60	54	24	25	65	52	91	28	28	51	46	30	84	49	89	33	33	60
70	63	27	29	92	61	73	32	99	60	04	35	98	58	22	38	88	70
80	72	31	34	20	70	55	37	71	68	61	41	12	66	51	44	44	80
90	81	35	38	47	79	37	42	43	77	19	46	26	74	83	50	00	90
100	90	39	42	75	88	19	47	13	85	77	51	41	83	14	55	55	100
200	180	78	85	50	176	38	94	26	171	54	102	82	166	28	111	11	200
	E	W	N	S	E	W	N	S	E	W	N	S	E	W	N	S	
	5 Points ¾				5 Points ½				5 Points ¼				5 Points.				
	64 deg. 42 m.				61 deg. 52 m.				59 deg. 04 m.				56 deg. 15 m.				

A Traverse-Table *for every* Point, Half-Point, *and* Quarter-Point *of the* Compass, *to the* 100 *part of a* League *or* Mile; *which gives the* Diff. *of* Lat. *and* Depar. *from the* Meridian.

Diff. in Miles just.	36 deg. 34 m. — 3 Point ¼				39 deg. 22 m. — 3 Points ½				42 deg. 11 m. — 3 Points ¼				45 deg. 00 m. — 4 Points.				Diff. in Leag. or Miles just.
	N	S	E	W	N	S	E	W	N	S	E	W	N	S	E	W	
1	00	80	00	60	00	77	00	63	00	74	00	67	00	71	00	71	1
2	01	61	01	19	01	55	01	27	01	48	01	34	01	41	01	41	2
3	02	41	01	41	02	32	01	90	02	22	02	01	02	12	02	12	3
4	03	21	02	38	03	09	02	54	02	96	02	69	02	83	02	83	4
5	04	02	02	98	03	86	03	17	03	70	03	36	03	54	03	54	5
6	04	82	03	57	04	64	03	81	04	44	04	03	04	24	04	24	6
7	05	62	04	17	05	41	04	44	05	18	04	78	04	95	04	95	7
8	06	43	04	76	06	18	05	07	05	93	05	37	05	66	05	66	8
9	07	23	05	36	06	96	05	71	06	67	06	04	06	36	06	36	9
10	08	03	05	96	07	73	06	34	07	41	06	72	07	07	07	07	10
11	08	83	06	55	08	50	06	98	08	15	07	39	07	78	07	78	11
12	09	64	07	15	09	28	07	61	08	89	08	06	08	49	08	49	12
13	10	44	07	74	10	05	08	25	09	63	08	73	09	19	09	19	13
14	11	24	08	34	10	82	08	88	10	37	09	40	09	90	09	90	14
15	12	05	08	94	11	60	09	52	11	11	10	07	10	61	10	61	15
16	12	85	09	53	12	37	10	15	11	85	10	74	11	31	11	31	16
17	13	66	10	13	13	14	10	78	12	70	11	42	12	02	12	02	17
18	14	46	10	72	13	91	11	42	13	34	12	09	12	73	12	73	18
19	15	26	11	32	14	69	12	04	14	08	12	76	13	44	13	44	19
20	16	06	11	91	15	46	12	69	14	82	13	43	14	14	14	14	20
21	16	87	12	51	16	23	13	32	15	56	14	10	14	85	14	85	21
22	17	67	13	11	17	01	13	96	16	30	14	77	15	56	15	56	22
23	18	47	13	70	17	78	14	59	17	04	15	45	16	26	16	26	23
24	19	28	14	30	18	55	15	22	17	78	16	12	16	97	16	97	24
25	20	08	14	89	19	32	15	86	18	52	16	79	17	68	17	68	25
26	20	88	15	49	20	10	16	49	19	26	17	46	18	38	18	38	26
27	21	69	16	08	20	87	17	13	20	00	18	13	19	09	18	09	27
28	22	49	16	68	21	64	17	76	20	75	18	71	19	80	19	80	28
29	23	29	17	27	22	42	18	40	21	49	19	44	20	51	20	51	29
30	24	10	17	87	23	19	19	03	22	23	20	12	21	21	21	21	30
31	24	90	18	47	23	96	19	67	22	97	20	82	21	92	21	92	31
32	25	70	19	06	24	74	20	30	23	71	21	49	22	63	22	63	32
33	26	51	19	66	25	51	20	93	24	45	22	16	23	33	23	33	33
34	27	31	20	25	26	28	21	57	25	19	22	83	24	04	24	04	34
35	28	11	20	85	27	06	22	20	25	93	23	50	24	75	24	75	35
36	28	91	21	46	27	83	22	84	26	67	24	17	25	46	25	46	36
37	29	72	22	04	28	60	23	47	27	41	24	85	26	16	26	16	37
38	30	52	22	64	29	37	24	11	28	16	25	52	26	87	26	87	38
39	31	33	23	23	30	15	24	74	28	90	26	19	27	56	27	56	39
40	32	13	23	83	30	92	25	38	29	64	26	86	28	28	28	28	40
41	32	93	24	42	31	69	26	01	30	38	27	53	28	99	28	99	41
42	33	73	25	02	32	47	26	64	31	12	28	21	29	10	29	10	42
43	34	54	25	61	33	24	27	28	31	86	28	88	30	41	30	41	43
44	35	34	26	21	34	01	27	91	32	60	29	55	31	11	31	11	44
45	36	14	26	81	34	78	28	55	33	34	30	22	31	82	31	82	45
46	36	94	27	40	35	56	29	18	34	08	30	89	32	53	32	53	46
47	37	75	28	00	36	33	29	82	34	82	31	56	33	23	33	23	47
48	38	55	28	59	37	10	30	45	35	57	32	23	33	94	33	94	48
49	39	36	29	19	37	88	31	08	36	31	32	91	34	65	34	65	49
50	40	17	29	78	38	65	31	72	37	05	33	58	35	35	35	35	50
51	40	96	30	38	39	42	32	35	37	79	34	25	36	06	36	06	51
52	41	77	30	98	40	20	32	99	38	53	34	92	36	77	36	77	52
53	42	57	31	57	40	97	33	62	39	27	35	59	37	48	37	48	53
54	43	37	32	17	41	74	34	26	40	01	36	26	38	14	38	14	54
55	44	18	32	76	42	52	34	86	40	75	36	94	38	89	38	89	55
56	44	98	33	36	43	29	35	53	41	49	37	61	39	60	39	60	56
57	45	78	33	96	44	06	36	16	42	23	38	28	40	30	40	30	57
58	46	59	34	55	44	83	36	79	43	07	38	95	41	01	41	01	58
59	47	39	35	15	45	61	37	43	43	72	39	62	41	72	41	72	59
60	48	19	35	74	46	38	38	06	44	45	40	29	42	43	42	43	60
70	56	22	41	69	44	11	44	41	51	85	47	00	49	49	49	49	70
80	64	25	47	65	61	84	50	75	59	26	53	72	56	56	56	56	80
90	72	28	53	61	69	57	57	09	66	67	60	44	63	63	63	63	90
100	80	32	59	56	77	30	63	43	74	08	67	15	70	71	70	71	100
200	160	64	119	12	154	60	126	86	148	16	134	30	141	41	141	41	200
	E	W	N	S	E	W	N	S	E	W	N	S	E	W	N	S	
	4 Points ¼				4 Points ½				4 Points ¼				4 Points.				
	53 deg. 26 m.				50 deg. 37 m.				47 deg. 49 m.				45 deg. 00 m.				

Another Example I will give of a ſuppoſed Reckoning between Lundy *and* Barbadoes; *As follows.*

Suppoſe a Ship ſail from the Iſland of *Lundy*, in *Latitude* 51 deg. 22 min. North, and *Longitude* 25 deg. 52 min. towards the *Iſland* of *Barbadoes*, in *Latitude* 13 deg. 10 min. *North*, and *Longitnde* 332 deg. 57 min. By the *Plain-Chart*, *Difference* of *Latitude* is 764 *Leagues*, and *Longitude* 1058 *Leagues*, and I ſail theſe ſeveral *Courſes*, (*viz.*) *S. S. W.* half *W.* from A to B. 400 *Leagues*, *S. W. b. S.* half *W.* 125 *Leagues*, and *S. W.* 192 *Leagues*; and *S. W. b. W.* half *Weſterly* 190 *Leagues*; *W. S. W.* 146 *Leagues*, and *W. b. S.* 159 *Leagues*. All theſe *Courſes* and *Diſtances* I ſet down as followeth.

In the firſt *Column* is expreſſed the *Days* of the *Month*; The ſecond, the *Day* of the *Week*; The third, the *Courſe* Sailed; The fourth, the *Diſtance* from the *Meridian*; The fifth, the *Place* and *Point* of each *Courſe* by *Letters*; The ſixth, the *Diſtance* ſailed; The ſeventh, eighth, ninth, and tenth, the *Northing*, *Southing*, *Eaſting*, and *Weſting*, which is the *Difference* of *Latitude* and *Departure* from the *Meridian* in *Leagues* and tenth *Parts*; The eleventh *Column* is the *Latitude*; The twelfth, the *Longitude*.

Da. Month.	Da. Week.	Courſe Sailed.	Diſtance from the Meridian.	The Places.	Diſt. Sailed.	North. ing.	South- ing.	Eaſt- ing.	Weſt- ing.	Latitu. Degr.	Latitu. Min.	Longit. Degr.	Longit. Min.
Apr. 21	f	S. W. ½ W.	S.W. 54 *d.* 10 *m.*	From A to K.	1305 League.	*Leagu.*	764 *Leagu.*	*Leag*	1058 *Leag.*	51 13	22 10	25 332	52 57
May 2	c	S.S.W. ½ W.	S.W. 2 *Po.* ½	From A to B.	200 200		176 4/10 176 4		94 3/10 94 3	33	43	16	25
6	G	S.W.b.S. ½ W.	S.W. 3 *Po.* ½.	From B to C.	100 20 5		773 155 39		634 127 32	28	52	12	28
10	d	S. W.	S.W. 4. *Points*	From C to D.	100 80 12		707 566 85		707 566 85	22	04	5	40
15	b	S. W. by W. ½ W.	S. W. 5 *Po.* ½	From D to E.	100 90		471 424		882 794	17	34	357	16
19	f	W. S.W.	S. W. 6. *Points.*	From E to F.	100 40 6		383 153 23		924 370 55	14	46	350	31
24	d	W. by S.	S. W. 7 *Points*	From F to G.	100 50 9		195 98 18		981 490 88	13	13	342	43

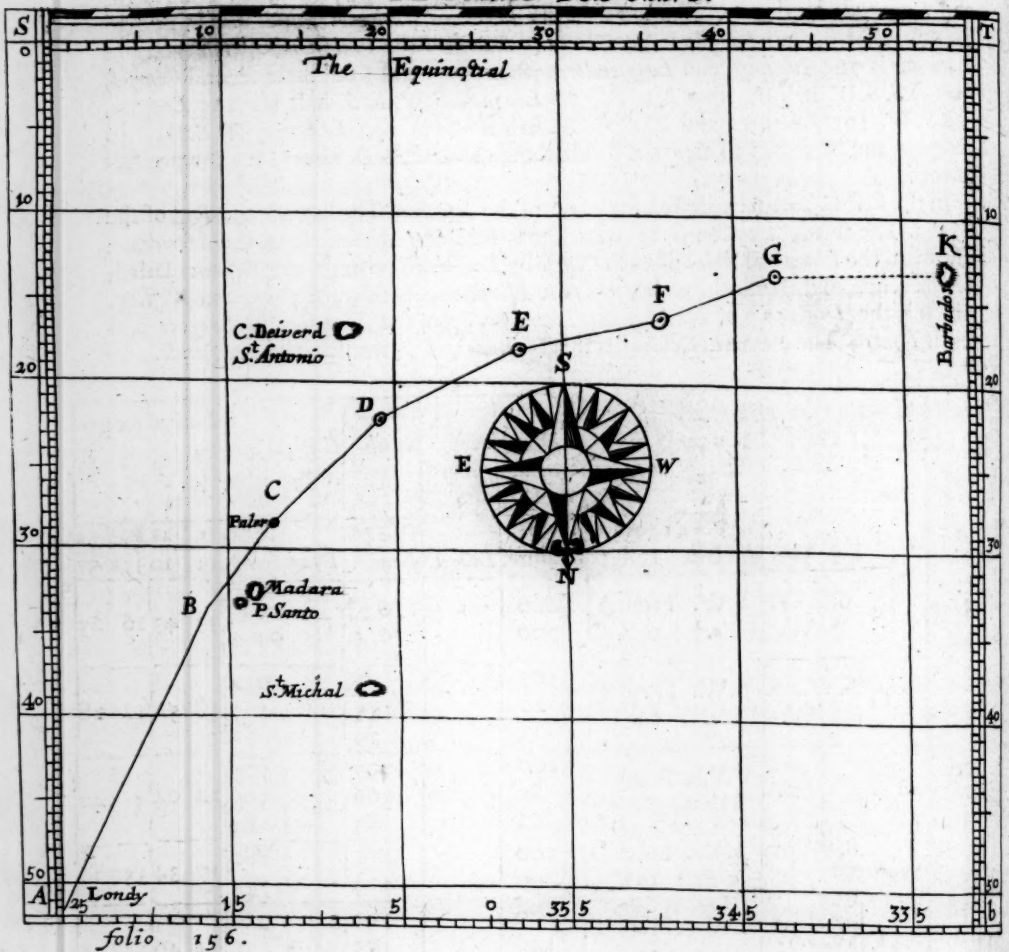
Note, When we ſet ſail, we put down the day of the Month and Week, the direct *Courſe* to the Port we are bound to, and the *Place* marked with two Letters, as in this *Table*, A for *Lundy*, and K for *Barbadoes*; and alſo under *Diſtance*, the number of *Leagues* upon a ſtraight *Courſe*; and under Northing or Southing, the Difference of *Latitude* in *Leagues* and *Tenth Parts*; and under Eaſting and Weſting, the Departure in *Leagues*; and under *Latitude*, the *Latitude* of the two *Places*; and under *Longitude*, the *Longitude* of the two *Places*; which you may ſee in the Head of the *Table*, againſt the 21 of *April*.

Now if you would ſet down this *Reckoning* on the *Plain-Chart*, take theſe following Directions.

And

And first, How to Describe a Plain-Chart.

The Plaine Sea Chart.



folio 156.

MAke the Square A S T B, of what length and breadth you pleaſe, and divide each Side into as many equal Parts repreſenting degrees, as your occaſion requires; and then draw ſtraight Lines through theſe Parts, croſſing one the other at *Right Angles*, ſo making many little *Geometrical Squares*, each of which contain one Degree: but I have made them here for want of Room to contain 10 Degrees. So that you may make the Primary Meridian in your Chart 25 *deg.* 52 *min.* to the Weſtward of the Meridian of *Lundy*, and you may divide the two Sides into Degrees as far as you think fit, and every Degree into 6 or 10 Parts as the Degrees will permit. This is ſo plain, it needs no further Precept; therefore we will proceed to the uſe of it.

Now your ſeveral *Courſes* and *Diſtances* are laid down on this *Chart*, from *Lundy* at A, to B, the ſecond to C, the third to D, the fourth to E, the fifth to F, the ſixth to G. either by the Line of Chords on the Plain Scale, or elſe by the *Protractor*, deſcribed, *Pag.* 639. Lay off your firſt *Courſe* from the Meridian A S, upon the Line A B;

A B, and lay off your distance 400 *Leagues* or 20 *Degrees* (taken from the Chart) from A to B, then laying the Edge of the *Protractor* parallel to the *Meridian*, A S, or any other; Lay off your second Course upon the Line B C, and your Distance in Degrees from B to C, and so proceed with the rest, till you come to G, which is the place where the Ship is the 24*th* day at noon. But the Place where the Ship is at any time, may be more easily found by the help of the *Table* preceding, containing the Reckoning between *Lundy* and the *Barbadoes*. In the said *Table* you have the *Latitude* and *Longitude* the Ship is in every Day at Noon; so that the 24*th* day the Ship is in the *Lat.* 13 d. 13 m. Northerly, and in the *Longitude* of 34 d. 43 min: Therefore setting your *Compasses* in the *Longitude* of *Lundy*, extend the other Point to 342 deg. 43 min, then setting one point of your Compasses in the *Latitude* 13 deg. 13 min. in the *Meridian*, passing through *Lundy*, with the former extent, place the the other point Parallel to an *East* and *West* Line, that Point of the Compasses shall shew the Place where the Ship is, which is G; whereby you will find the *Barbadoes* to Bare *West*, and to be Distant 180 *Leagues* or 9 Degrees.

CHAP IV.

How to Correct the Account, *when the* Dead Latitude *differs from the* Observed Latitude.

WE are come now to make good what was promised in the second *Chapter*, to prescribe four *Precepts* for correcting a *Single Course*.

I shall be brief, following Mr. *Collins*, in *pag.* 22. of his *Mariner's Scale new Plained*, who hath imitated *Mœtius* in these *Examples*.

The first Rule.

IF a Ship sail under the *Meridian*, if the Difference of *Latitude* be less by Estimation, than it is by Observation, the Ship's Place must be corrected and enlarged under the *Meridian*; and the Error is to be imputed either to the Judgment in estimating the Distance run, in making it too little; or if the said Distance be well estimated with good Judgment, it is to be supposed you stem some *Current*.

Admit a Ship sail from A, in the *Latitude* of 36 *deg.* directly South, 70 *Leagues*, or 3 *deg.* 30 *min.* by Estimation, and so is at B, in the *Latitude* 32, 30, but by Observations he is in the *Latitude* 32 *deg.* The Reckoning rectified, the Ships place is in the *Point* C; but if the Difference of *Latitude* be more by Estimation, than it is by Observation. In this Case, the *Distance* is to be shortned, and the Correction must be made according to the *Latitude* observed under the *Meridian*.

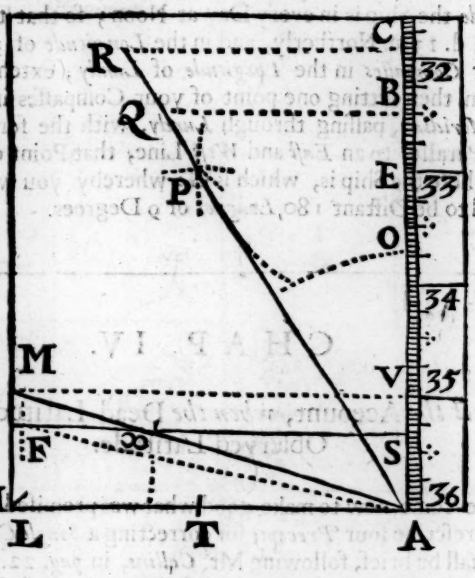
Admit a Ship sail South from A, in the *Latitude* 36 *deg.* untill she have altered her *Latitude* 3 *deg.* 30 *min.* by Estimation being at B, in *Latitude* 32 *deg.* 30 *min.* and if the observed *Latitude* be 33 *degrees* 00 *min.* the Ship's Place corrected is at E. and not at B.

RULE II.

SUpposing no *Current*, If the Ship sail within 5 Points of the *Meridian*, and the *Dead Latitude* differ from the observed *Latitude*, the Error is in misjudging the Distance run, which is to be made longer or shorter as the Case requires.

Admit a Ship sail from A, *S. S. E.* $\frac{1}{4}$ *Easterly* 70 *Leagues*, and is by Estimation at P in the *Latitude* of 33 *deg.* but if the observed *Latitude* be 32 *deg.* 30 *min.* admit at B, then a *Line* drawn through B, parallel to N A, crosseth the *Line* of the Ships *Course* at Q, which is the Corrected Point where the Ship is: So that the Distance is enlarged 11 *Leagues* $\frac{6}{10}$, the whole *Distance* A Q is 81 *Leagues* $\frac{6}{10}$.

In the same manner, If the Ship had sailed 94 Leagues on the same Course, and by Estimation were at the Point R, in the *Parallel* of 32 *deg.* and by Observation the Latitude were found to be 32 *deg.* 30 *min.* In this Case the Ships Distance is to be shortned, by drawing the foresaid Line B Q parallel to N A; and it will cross the Line of the Ships Course at Q, the Corrected Point where the Ship is.



RULE. III.

Suppose there is some *Current*, if the Ship sail East or West, but you can depend upon the Observed Difference of Latitude and Log-distance, as both true; then the Error may be imputed to the *Rhomb*, which alters by reason of the supposed *Current*.

Then retain the Observed Difference of Latitude, and Distance, and thereby find the Departure from the Meridian, by drawing a new *Rhomb-line*.

But if your Judgment would allot the Error to the Distance, onely keep the observed Difference of Latitude: And the Course the same as was by the *Dead-reckoning*.

Suppose a Ship sail East by South, half a Point Southerly 69 Leagues, from the Latitude of 36 *deg.* from A to M, and by Dead Reckoning should be in the Latitude of 35 *deg.* If the observed Latitude be 35 *deg.* 20 *min.* which is at S; In this Case, If the Error be wholly imputed to the Distance, the Line S X being drawn parallel to N A, would cut off or shorten the Distance as much as the Measure M X, which is 23 Leag. which because it seems absurd and improbable, is not to be admitted of: Wherefore imputing the Error to the *Rhomb* only, with the Extent A M, describe an Arch as at F, and extend the Parallel S X till it pass through the said Arch at F, then the Course is upon the Line A F, which is E. b. S. differing half a Point from the Course Steered.

RULE IV.

If a Ship sail East or West, and the Dead and Observed Latitude do agree, the *Reckoning* cannot be corrected; but if they differ, impute the Error partly to the *Rhomb* and partly to the Distance; and so Correct your *Reckoning* according to discretion.

CHAP.

By the Traverſe-Scale.

EXtend the Compaſſes from 100, to the Diſtance Sailed; the ſame Extent will reach from the Difference of *Latitude* by Obſervation, to the true Courſe: So that you may in a moment do all theſe Queſtions and Caſes by the *Traverſe-Scale*, and *Line* of *Numbers* and *Artificial Points* and *Quarters* thereon. If you have but the perfect Uſe of it, I know there is no Inſtrument whatſoever more ready to reſolve any uſeful Queſtion, and Correct your Reckoning.

Laſtly, If by frequent Obſervation you find the Ship is ſtill carried from the Eaſt or Weſt, either Northward or Southward, you may conclude ſome Current to be the Cauſe thereof: Keep the Diſtance by Dead Reckoning and Obſervation, and the Difference is the Diſtance from the Parallel.

We will not multiply too many Examples, but rather adviſe the ingenious to make uſe of ſuch as his need ſhall require; for underſtanding what hath been ſaid, will be advantagious to the Practitioner.

CHAP. V.

How to allow for known Currents, *in Eſtimating the Ships* Courſe *and* Diſtance.

THis Subject hath been largely handled by Mr. *Norwood*, at the end of his *Sea-mans Practice*; and by Mr. *Phillips*, in his *Advancement of Navigation*, *p.*54, to 64. As alſo how to find them out by comparing the Reckoning homeward with the Reckoning outward, which was kept betwixt two Places: Therefore I ſhall be brief, and work by *Scale* and *Compaſs*, what they have done by *Tables*.

Firſt, This is eaſie to be underſtood, If you ſail againſt a *Current*, if it be ſwifter than the Ships way, you fall a ſtern; but if it be ſlower, you get on Head ſo much as is the Difference between the Way of the Ship, and the Race of the Current.

EXAMPLE.

If a Ship ſail 8 Miles South in an Hour, by *Log* or *Eſtimation*, againſt a Current that ſets North 3 Miles in an Hour, that Subtracted from 8, leaves 5 Miles an Hour the Ship goes a head South: but if the Ships way were 3 Mile an Hour South, againſt a Current that ſets 8 Miles an Hour North, the Ship would fall a Stern 5 Miles an Hour.

	mil.
South	8
Current	3
Goes a Head	5 S.

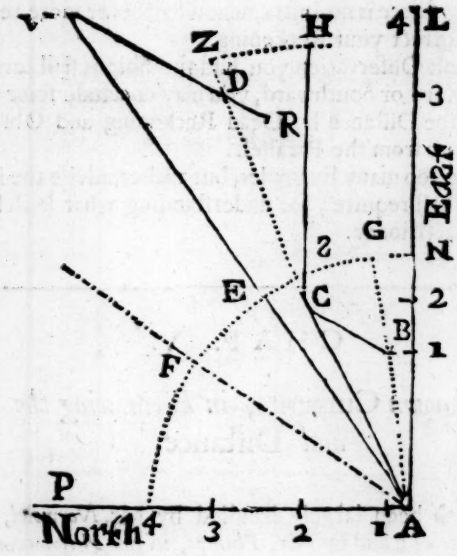
Admit a Ship runs Eaſt 4 Miles an Hour, and the Current runs Eaſt alſo 3 Miles an Hour, What is the true Motion of the Ship?

Anſwer, 7 Miles an Hour a Head.

	mil.
Current	8
Ships Way	3
Falls a Stern	5

Admit a Ship croſs a Current that ſets North East-by-North 4 Miles an Hour; The Ship Sails in a Watch, or 4 Hours, 9 *Leagues* East-by-North, and in two Watches more ſhe ſails 13 *Leagues* East-North-East by the *Compaſs*.

Now it is required to find what Courſe and Diſtance the Ship hath made her way good from the firſt place of ſetting out from A.



Firſt draw the *Right Line* A L, then with the *Chord* of 60 *degrees* deſcribe the *Quadrant* on it; Take 90 *degrees* off the *Line* of *Chords*, and lay it from N to O; then draw the *North Line* A P; then ſet off the Ship's firſt *Courſe* one Point from the Eaſt from N to G, and draw the *Line* A G, and from A to B lay off the firſt Diſtance 9 *Leagues*: Then prick off the *Courſe* of the *Current*, being 5 *Points* from N to F, and draw the *Line* A F, being the *Courſe* North East-by-North of the *Current*.

And becauſe the *Current* in 4 Hours ſets 5 *Leagues* three *Quarters* forward in its own Race, therefore draw the *Line* B C, parallel to A F, that is, take the neareſt Diſtance from B to A F, and ſweep a ſmall *Arch* over the *Line* A F, and from B to the upper Edge of the *Arch*, draw the *Line* B C, and thereon put from B to C 5 three *Quarters*, the *Currents Motion*, and draw the *Line* A C, which ſhews the *Courſe* the Ship hath made good the firſt *Watch*.

Now for the ſecond *Courſe* draw C H parallel to the *Line* A L, and with the *Radius* or *Chord* of 60 *degrees* upon C as a *Center*, draw the *Arch* H Z, whereon prick 22 *degrees* 30 *minutes*, or 2 *Points* for East-North-East for the Ship's ſecond *Courſe* from the Eaſt; and draw C Z, whereon prick down the *Diſtance* Sailed 13 *Leagues* from C to D; then draw D W parallel to A F as you did B C; then becauſe the *Current* ſets 10 $\frac{2}{3}$ in two *Watches*, therefore prick down 10 $\frac{2}{3}$ *Leagues* from D to W, and draw the *Line* A W; which being meaſured upon the ſame *Scale* (of an *Inch* divided into 10 parts) ſhews the Ship's direct diſtance is 35 *Leagues* and a half; whereas if there had been no *Current*, the direct *Diſtance* had been A R 22 Leagues.

Then meaſure the *Arch* N E, and you will find it 34 *degrees*, which is a little above 3 *Points* from the Eaſt.

So the *Point* the Ship hath made good is North-East-by-East a little Northerly; whereas if there had been no *Current*, the *Courſe* had been N S, that is, Eaſt and by North half a *Point* Northerly.

Some

Some will expect that know me, ſome other ſort of Queſtions (beſides theſe foregoing:) For them, and their leiſure-time, I have inſerted theſe Queſtions following.

QUEST. I.

A Ship Sails 40 Leagues *more than her Difference of* Latitude, *and is departed from the* Meridian 80 Leagues; *I demand her* Difference *of* Latitude.

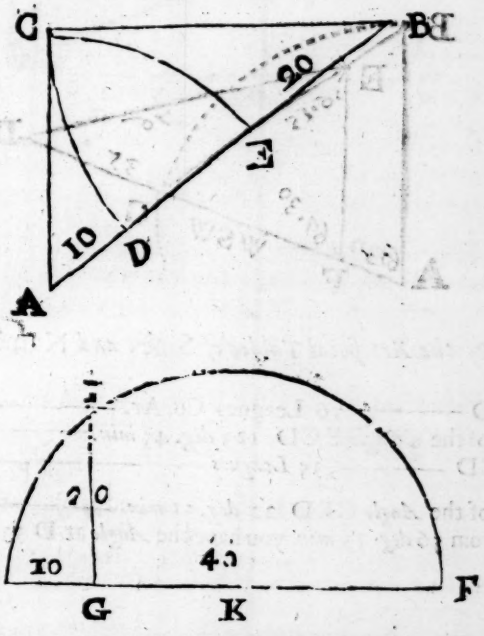
DOuble the Exceſs of the Diſtance above the Difference of *Latitude*, which makes 80, then to the *Departure* 80, add the ſaid Exceſs 40, the Sum is 120; and likewiſe ſubtract the Exceſs from the *Departure*, the Difference is 40. Then ſay, By the *Rule of Three*,

As 80, to 120:
So is 40. to 60.
Which is the Difference of *Latitude* required.

This may be *Geometrically* performed by *Problem* 14. *pag.* 30.

QUEST. II.

A Ship Sails 20 Leagues *more than her Difference of* Latitude, *and* 10 Leagues *more than her* Departure *from the* Meridian, *I demand her* Diſtance *Sailed.*



IN the *Triangle* A B C, you have A B 20 *Leagues* more than the Difference of *Latitude* A C; and 10 *Leagues* more than the *Departure* from the *Meridian* B C.

Firſt, With the double of either *Number*, which here I take, the double of E B 20 which is 40 *Leagues*, and lay from F unto G: then I take the other *Number* A D 10, and add it thereunto, as G H. Now on the middſt of F H, as at K, making it the *Center*, I deſcribe the *Semicircle* H I F.

Then on G erect the *Perpendicular* which cuts the *Arch* in I; Then meaſuring

G I,

G I, it will be equal to D E 20 *Leagues*, which added to the two former *Numbers* 20 and 10, you have in all 50 *Leagues* for the *Diſtance* Sailed, required.

Arithmetically.

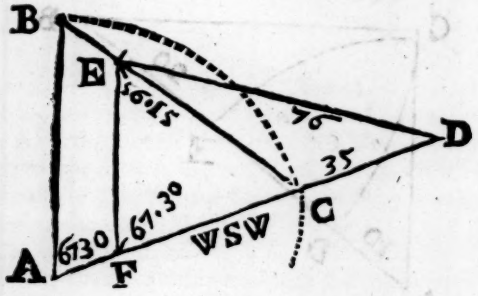
Multiply A D 10 by B E 20, which produces 200, Double this Product, which makes 400, out of this double Product Extract the *Square Root*, which is 20.

QUEST III.

Two Ships Sail from one Port: The firſt Sailes directly South, the ſecond Ship Sails W. S. W. *more than the firſt by* 35 Leagues, *and then were aſunder* 76 Leagues : *The* Queſtion *is, How many* Leagues *each Ship Sailed.*

First draw the *Meridian-line*, A B and from A draw a W. S.W. *Line*, as A D, and from C (where the Chord of 60 *deg.* cuts the *Line* A D) lay down the 35 Leagues unto D. Now draw the *Chord-Line* B C; then take 76 Leagues, and lay it from D to cut the *Chord-line* in E.

Laſtly, From E you muſt draw a Parallel *Meridian*, which will cut the *Rhomb-line* in F; ſo meaſuring E F, you ſhall have 45 *Leagues* and a half, that the firſt Ship Sailed directly *South*: and the ſecond Ship ſailed 35 *Leagues* and a half more, that is 80 *Leagues* and a half, the *Diſtance* required.



By the Artificial Tables of Sines *and* Numbers.

As the *Side* E D ——— 76 Leagues Co. Ar. ———	811919
To the *Sine* of the *Angle* E C D 123 *deg.* 45 *min.* ———	991985
So is the *Side* C D ——— 35 *Leagues* ———	154407
To the *Sine* of the *Angle* C E D 22 *deg.* 31 *min.* ———	958311

Which ſubtract from 56 *deg.* 15 *min.* you have the *Angle* at D 33 *deg.* 44 *min.*

Then,

As the *Sine* of the *Angle* at F 67 *deg.* 30 *min.* Co. Ar. ———		001438
Is to his oppoſite *Side*, ——— E D 76 Leagues	*add*	188081
So the *Sine* of the *Angle* at D 33 *deg.* 44 *min* ———		974455
To his oppoſite *Side* ——— F E 45 $\frac{81}{100}$ Leagues ———		165974

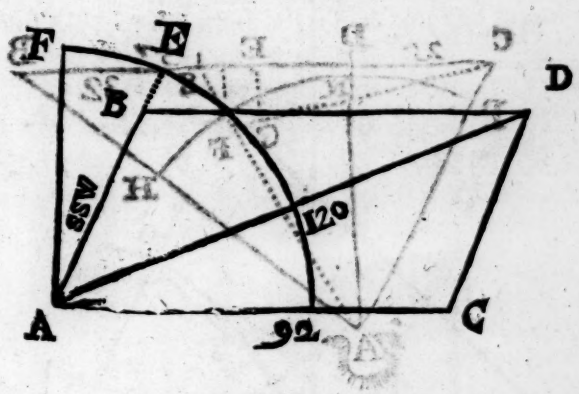
So the firſt Ship Sailed 45 $\frac{81}{100}$ Leagues; and the other $\frac{81}{100}$ Leagues.

QUEST.

QUEST. IV.

Two Ships Sailed from one Port: *The firſt Sails* S. S. W. *a certain* Diſtance; *then altering her* Courſe, *ſhe Sails due Weſt* 92 Leagues: *The ſecond Ship Sailing* 120 Leagues *meets with the firſt Ship. I demand the ſecond Ship's* Courſe, *and how many* Leagues *the firſt Ship Sailed* S. S. W.

DRaw the firſt Ship's *Rhomb* from A unto E, being *S. S. W.* then lay her *Diſtance* ſailed Weſt 92 Leagues from A unto C, and from C draw a *S. S. W.* Line as CD continued: Next take 120 Leagues, and lay it from A, ſo that it ſhall cut the Line CD in D: So drawing AD, you ſhall have the ſecond Ship's Courſe near *Weſt South Weſt.* Laſtly, meaſuring CD equal to AB, you ſhall find it to be 49 Leagues and a half that the firſt Ship Sailed, *S. S. W.*



For the two Ships Courſe.

As the Side AD —— 120 Leagues,	—— Co. Ar. ——	792082
Is to the Sine of the Angle at B 112 *deg.* 30 *min.*	——	996562
So is the Sine of the Side BD 92 Leagues	——	196379
To the Sine of the Angle BAD 45 *deg.* 6 *min.*	——	985023

Unto which add the *Angle* FAB 22 *deg.* 30 *min.* you have the Second Ship's *Rhomb* 67 *deg.* 36 *min.* being near *W. S. W.* whoſe *Complement* is the *Angle* ADB 22 *deg.* 24 *min.*

For the Diſtance of the Ships.

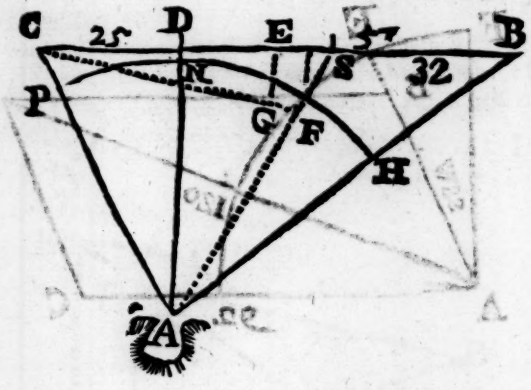
As the Sine of the Angle — BAD 45 *deg.* 6 min.	Co. Ar. ——	014976
Is to the Side —— BD 92 Leagues	——	196379
So is the Sine of the Angle — ADB 22 *deg.* 24 *min.*	——	958101
To the Side AB 49 $\frac{1}{10}$ Leagues required	——	169456

QUEST.

QUEST. V.

Two Ships ſail from one Port *upon two* Courſes 7 *Points aſunder: The one Sails in the* S. W. *Quadrant, and departs from the* Merid. 57 Leagues; *and the other Sailed in the* S. E. Quadrant, *and was departed from the* Meridian *but* 25 Leagues, *and then are both fallen into one* Latitude; *I demand the* Rhomb *or* Courſes *of each Ship.*

FIrſt draw an Eaſt and Weſt *Line* continued; and making choice of a *Point* at D, upon D ereſt a *Perpendicular*, which will be a *Meridian-Line*, as D A continued. Now from D lay down the Weſt Ship's *Departure* D B 57 *Leagues*; alſo the Eaſt Ship's *Departure* 25 *Leagues* D C: So their whole *Diſtance* will be C B 82 *Leagues*. Now upon the *Point* at B, or elſe as here at C, draw an *Angle* of the *Complement*, of 7 *Points*, that is 1 *Point*, as C F the prickt *Line*.



Now from the midſt between B and C, at E, draw another *Meridian-Line*, until it cut the former *Rhomb-Line* C F in the *Point* G: So taking the *Diſtance* from the *Point* G unto C, lay the ſame from G until it cut the *Meridian-Line*, in the *Point* A, which is the *Point* and *Port* you Sailed from.

1 *Courſe* S. W. ½ W.
2 *Courſe* S.S. E. ½ E.

Laſtly, From A you ſhall draw their *Rhombs* or *Courſes*, as A B, which is 4 half *Points* from the *South Weſt-wards*; and A C two half *Points* from the *South, Eaſt-ward.*

The Operation by the Logarithms.

As the Sum of their *Departures* C B 82 *Leagues*	191381
To the Difference of their *Departure* S B 32 *Leagues*	150515
So is the *Sine* of the Sum of their *Courſes* C A B 78 deg. 45 *min.*	999157
To the *Sine* of the *Difference* of their *Courſes*	1149672
S A B 22 *deg.* 30 *min.*	958291

Now 22 *deg.* 30 *min.* added to 78 *deg.* 45 *min.* the half *Sum* is 50 *deg.* 37 *min.* and a half; that is 4 *Points* and a half or *S. W.* half *W.* for the one Ships *Courſe* Sailed from A to B: and 22 *deg.* 30 *min.* ſubtracted from 78 *deg.* 45 *min.* the half Sum is 28 *deg.* 07 *min.* and a half; that is 2 *Points* and half or *S. S. E.* half a *Point Eaſterly*, the other Ship's *Courſe*.

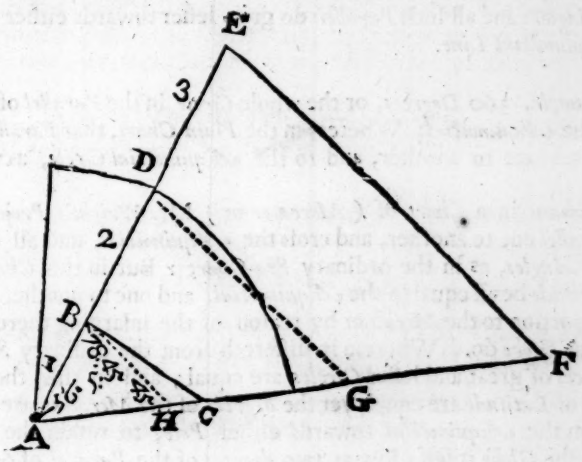
QUEST.

QUEST VI.

From the Port at A, *I Sail South-South-Weſt unto* B, *and from* B, *I Sail North-Weſt-by-Weſt unto* C, *and from* C, *I Sailed unto my firſt* Port *at* A, *Eaſt-by-North. Now having Sailed in all* 120 Leagues, *I would know how many* Leagues *I have Sailed upon each* Point.

FIrſt draw A B a *South-South-Weſt-Line*, then at a convenient Diſtance, as from B, draw a *North-Weſt-by-Weſt-Line*, and from A draw the oppoſite *Courſe* of *Eaſt-by-North*, which is *Weſt-by-South*, which will cut B C in C; ſo continue the *Sides* of the *Triangle*, as A B unto E, and A C unto F. Then lay B C from B unto D, and A C from D unto E. Then take 120 *Leagues*, and lay the ſame from A unto F: Next draw the Line E F, and from D and B draw *Parallels* thereunto, which will cut A F in G and H.

Laſtly, meaſuring A H, you ſhall have 33 $\frac{2}{3}$ *Leagues* that you have Sailed *South-South-Weſt*. And meaſuring H G, you ſhall have 39 *Leagues* $\frac{6}{10}$ *parts* that you have Sailed *North-Weſt-by-Weſt*. Alſo meaſuring G F, you ſhall have 46 $\frac{1}{4}$ *Leagues* near, that you have Sailed *Eaſt-by-North*, which makes in all near 120 *Leagues*.



Arithmetically, *By the Table of* Natural Sines *in the* Sea-man's Kalendar.

Firſt, Add up all the *Sines* of the *Angles* together,

deg.	*min.*		
45	00	*Sine*	7071
56	15		8315
78	45		9808
			25194

Then by the *Rule* of *Three*.

As 25194, to 120 *Leagues*: So { 7071, 8315, 9808 } *Diſtance* failed { To the S. S. W. 33 $\frac{68}{100}$ A B. N. W. b. W. 39 $\frac{60}{100}$ *Leagues*. E. b. N. 46 $\frac{72}{100}$ C A.

CHAP. VII.

The Disagreement betwixt the Ordinary Sea-Chart, *and the* Globe; *And the Agreement between the* Globe *and the* True Sea-Chart, *made according to Mr.* Edward Wright's *Projection.*

THE *Meridians* in the ordinary Sea-Chart are *Right Lines*, all parallel one to another, and consequently do never meet; yet they cut the *Æquinoctial*, and all Circles of *Latitude*, at *Right Angles*, as in the *Terrestrial Globe*: But herein it differeth from the *Globe*, for that here all the *Parallels* to the *Æquinoctial* being lesser *Circles*, are made equal to the *Æquinoctial* it self, being a great *Circle*; and consequently the *Degrees* of those *Parallels* or lesser *Circles*, are equal to the *Degrees* of the *Æquinoctial*, or any other great *Circle*, which is meerly false, and contrary to the nature of the *Globe*.

The *Meridians* in the *Terrestrial Globe* do all meet in the *Poles* of the *World*, cutting the *Æquinoctial*, and consequently all *Circles* of *Latitude*, or *Parallels* to the *Æquator* at *Right Angles*: and all such *Parallels* do grow lesser towards either *Pole*, decreasing from the *Æquinoctial Line*.

As for *Example*, 360 *Degrees*, or the whole *Circle* in the *Parallel* of 60 *deg.* is but 180 *deg.* of the *Æquinoctial*; Whereas in the *Plain Chart*, that *Parallel* and all others are made equal one to another, and to the *Æquinoctial Circle*, as we have said before.

The *Meridians* in a *Chart* of (*Mercator* or) Mr. *Wright's Projection*, are *Right Lines*, all *Parallel* one to another, and cross the *Æquinoctial*, and all *Circles* of *Latitude*, at *Right Angles*, as in the ordinary *Sea-Chart*: But in this *Chart*, though the *Circles* of *Latitude* be all equal to the *Æquinoctial*, and one to another, yet they keep the same proportion to the *Meridian* by reason of the inlarging thereof, as the same *Parallels* in the *Globe* do. Wherein it differeth from the ordinary *Sea-Chart*, for in that the *degrees* of great and lesser *Circles* are equal; and in this, though the *degrees* of the *Circles* of *Latitude* are equal, yet the *degrees* of the *Meridian* are unequal, being inlarged from the *Æquinoctial* towards either *Pole*, to retain the same *Proportion* as they do in the *Globe* it self; For as two *degrees* of the *Parallel* of 60 *deg.* is but one of the *Æquinoctial*, or any *Great Circle* upon the *Globe*, so here two *degrees* of the *Æquinoctial*, or of any *Circle* of *Latitude* is but equal to one *degree* of the *Meridian*, betwixt the *Latitude* of 59 ½ and 60 ½ *deg.* and so of the rest.

Now for the making of this Table of *Latitudes* or *Meridional Parts*, it is by an addition of *Secants*; for the *Parallels* of *Latitude* are less than the *Æquator* or *Meridian*, in such proportion as the *Radius* is to the *Secant* of the *Parallel*.

For Example. The *Parallel* of 60 *deg.* is less than the *Æquator*; and consequently each *degree* of this *Parallel* of 60 *deg.* is less than a *deg.* of the *Æquator* or *Meridian*, in such proportion as 100000 *Radius*, hath to 200000 the *Secant* of 60 *degrees*.

Now to shew how Mr. *Gunter* and Mr. *Norwood's Tables* are made, which was by the help of Mr. *Edward Wright's Tables* of *Latitude*. Mr. *Gunter's* being an Abridgment, consisting of the *Quotient* of every sixth *Number*, divided by six, and two *Figures* cut off.

As for *Example.* In M. *Wright's* Tables of *Latitude* for 40 *degrees* the Number is 26227559.

That divided by 6, cutting off two *Figures*, the *Quotient* is 43 *deg.* 712 parts of the *Æquator*, to make 40 *deg.* of the *Meridian*.

And Mr. *Norwood's* Tables of *Meridional Parts*, is an Abridgment of Mr. *Wright's* Table of *Latitudes*; namely, every sixth Number cutting off four *Figures* to the right

right hand, as for 40 *deg.* as before the Number is 26. 227559, from which cutting off four Figures, makes the *Meridional parts* 2623, as you will find by this Table.

So this Table ſheweth how many parts every degree, and every tenth part of a degree of *Latitude* in this *Chart*, is from the *Æquinoctial*; Namely, of ſuch parts, as a *Degree* of the *Æquator* containeth 60. And this which I here exhibit, and call a *Table of Meridional Parts*, is alſo an Abridgment of the Table of *Latitudes* of Mr. *Wright*'s; Namely, omitting alwayes the three laſt *Figures* and dividing the reſidue by 3.

As for *Example*. The Numbers for 40 *deg.* are 26, 227, 559; omit the 3 laſt, and divide the reſt by 3, and in the *Quotient* is 8742, the *Meridional parts* for 40 *deg.* and ſo of the reſt: So that this Table ſheweth how many parts every *deg.* and every tenth *min.* of *Latitude* is from the *Æquinoctial* in *Leagues* and *Tenths*.

The Uſe of this Table ſhall partly appear in the *Problems* following.

PROBLEM I.

How to find by the following Tables *what* Meridional Parts *are contained in any* Difference *of* Latitude.

IN the following Table you muſt take the *Meridional Parts* anſwering to each *Latitude*, and ſubtract the leſſer from the greater; ſo the Remainer is the Number of *Meridional Parts* contained in the Difference of *Latitude* propoſed; except the two *Latitudes* be one Northerly, and the other Southerly, then add the *Meridional parts* together, and that Sum is the Difference of *Latitude* in *Meridional Parts*,

As, Let one *Latitude* be 51 *deg.* 20 *min.* N. —— 12002
And the other *Latitude* be 13 *deg.* 10 *min.* N. —— 2657 } *Meridional Parts.*

9345

The *Meridional Parts* contained in the Difference of *Latitude*, are 934 $\frac{5}{10}$ *Leagues.*

PROBL. II.

The Latitudes *of two* Places *being given, and* Difference *of* Longitude *of both* Places; *To find the* Rhomb *and* Diſtance.

TO the intent the Application may be the more evident, our *Examples* ſhall be of two Places before-expreſſed on the *Plain-Chart*.,

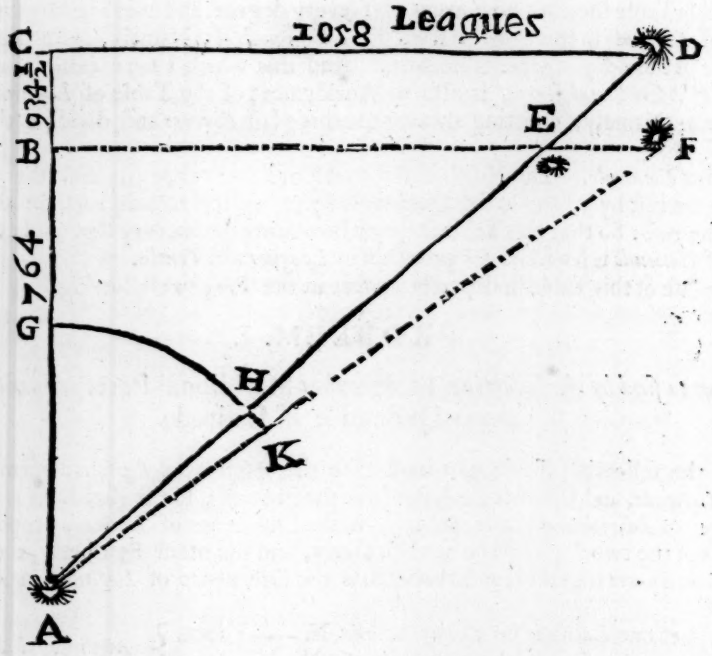
Suppoſe the *Latitude* of the Iſland of *Lundy* in the Mouth of *Seavern*, to be at A, 51 *deg.* 22 min. and the *Latitude* of *Barbadoes* 13 *deg.* 10 *min.* at B, and the Difference of *Longitude* 52 *deg.* 55 *min.* C D, that the *Barbadoes* is to the Weſtward of the Iſland of *Lundy*; The *Courſe* and *Diſtance* from the one Place to the other is demanded.

	Longitude. d.	m.
Lundy	25	52
	360	00
	385	52
Barbadoes	332	57
Differ.	52	55
	20	
	1040	
	18 $\frac{1}{3}$	
	1058	

51 d. 22. m.
13 10
38 12
20
760
4
764

Firſt you may demonſtrate the *Queſtion* by the *Scale*.

Draw the *Right Line* A C for the *Meridian*; and in regard the Difference of *Latitude* is 38 *deg.* 12 *min.* convert them into *Leagues*, by multiplying them by 20, and the odd *Minutes* divide by 3, and the Difference in *Leagues* will be 764; which lay from A to B, for the common Difference of *Latitude*.



Then take the Difference of the two *Latitudes* inlarged, 934 $\frac{1}{10}$ *Leagues*, and lay from A to C; then draw the two *Parallel Lines*, as B E and C D. Then 52 *deg.* 55 *min.* the Difference of *Longitude*, converted into *Leagues*, (as before directed) is 1058 $\frac{1}{3}$, which lay from C to D. and draw the *Line* A D, which is the true *Course* from A to D, and A E is the true Diſtance. And as D is the *Point* repreſenting *Barbadoes* by *Mercator's Chart*, ſo is E the *Point* repreſenting the ſame Place by the *Plain Chart*. And as C D is the *Longitude* by the *Globe*, ſo is B E the *Meridian-Diſtance* between *Lundy* and *Barbadoes*.

You will find the true *Courſe S. W.* a little more than a *Quarter Weſterly*, and the Diſtance is 1154 *Leagues*. Now by the *Plain Sea-Chart* the *Courſe* is B A F, *S. W.* above three quarters of a *Point Weſterly*; and the *Diſtance* is A F 1306 *Leagues*: So that the *Plain Chart* ſheweth the Diſtance more than it is by 152 *Leagues*, and the *Courſe* more *Weſterly* by half a *Point*, which is a groſs Error; and ſo groſly are thoſe Men miſtaken that uſe a *Plain-Chart*.

A Table

A Table of Meridional Parts *to the Tenth part of a* League, *and for every* 10 Minutes *of* Latitude *from the* Equinoctial.

DEGREES.

Minutes.	0	1	2	3	4	5	6	7	8	9	Minutes.
	lea. 1/10	lea. 1/10	lea. 1/10	lea. 1/10	lea. 1/10	lea. 1/10	lea. 1/10	lea. 1/10	lea. 1/10	lea. 1/10	
00	00	200	400	600	801	1001	1202	1403	1605	1807	00
10	33	233	433	634	834	1035	1236	1437	1639	1841	10
20	67	267	467	667	867	1068	1269	1471	1673	1875	20
30	100	300	500	700	901	1102	1303	1504	1706	1909	30
40	133	333	534	734	934	1135	1336	1538	1740	1943	40
50	167	367	567	767	968	1109	1370	1571	1774	1976	50
M	10	11	12	13	14	15	16	17	18	19	M
00	2010	2214	2418	2623	2828	3035	3242	3451	3661	3827	00
10	2044	2248	2452	2657	2863	3069	3277	3486	3696	3907	10
20	2078	2282	2486	2691	2897	3104	3312	3521	3731	3942	20
30	2112	2316	2520	2725	2931	3138	3347	3556	3766	3977	30
40	2164	2350	2554	2760	2966	3172	3381	3591	3801	4013	40
50	2180	2384	2588	2794	3000	3208	3416	3626	3836	4048	50
M	20	21	22	23	24	25	26	27	28	29	M
00	4084	4297	4512	4729	4947	5167	5388	5612	5837	6065	00
10	4119	4333	4548	4765	4983	5203	5425	5648	5875	6103	10
20	4155	4369	4584	4801	5020	5240	5462	5686	5913	6141	20
30	4196	4405	4620	4838	5056	5277	5500	5724	5951	6179	30
40	4226	4440	4656	4874	5090	5314	5537	5761	5989	6218	40
50	4262	4476	4692	4910	5130	5351	5574	5799	6027	6256	50
M	30	31	32	33	34	35	36	37	38	39	M
00	6294	6527	6761	6998	7238	7481	7726	7975	8217	2483	00
10	6333	6565	6800	7038	7278	7521	7768	8017	8270	8526	10
20	6371	6604	6840	7078	7319	7562	7809	8059	8312	8569	20
30	6410	6644	6879	7118	7359	7603	7850	8101	8355	8612	30
40	6449	6683	6919	7158	7400	7644	7892	8143	8397	8655	40
50	6488	6722	6938	7198	7440	7685	7934	8185	8440	8699	50
M	40	41	42	43	44	45	46	47	48	49	M
00	8742	9005	9272	9543	9819	10100	10385	10675	10971	11273	00
10	8786	9049	9317	9589	9865	10147	10433	10724	11021	11324	10
20	8829	9093	9362	9635	9912	10194	10481	10773	12071	11375	20
30	8873	9138	9407	9681	9959	10241	10530	10823	11121	11426	30
40	8917	9182	9452	9727	10005	10289	10578	10872	11172	11478	40
50	9961	9227	9498	9773	10052	10337	10626	10922	11222	11529	50
M	50	51	52	53	54	55	56	57	58	59	M
00	11581	11896	12217	12545	12881	13226	13581	13941	14313	14696	00
10	11633	11949	12271	12600	12938	13284	13640	14004	14377	14761	10
20	11685	12002	12325	12656	12995	13342	13700	14063	14440	14826	20
30	11737	12055	12380	12712	13052	13401	13759	14121	14504	14892	30
40	11790	12109	12435	12768	13110	13460	13820	14188	14568	14958	40
50	11842	12163	12490	12825	13168	13520	13881	14251	14632	15024	50
M	60	61	62	63	64	65	66	67	68	69	M
00	15091	15497	15917	16350	16798	17263	17745	18246	18769	19315	00
10	15158	15586	15988	16423	16874	17342	17827	18332	18858	19408	10
20	15225	15635	16059	16497	16951	17421	17920	18448	18948	19502	20
30	15293	15705	16131	16572	17028	17501	17993	18505	19035	19597	30
40	15300	15775	16204	16647	17106	17582	18077	18592	19130	19693	40
50	15428	15846	16277	16722	16184	17662	18161	18680	19222	19789	50
M	70	71	72	73	74	75	76	77	78	79	M
00	19886	20485	21116	21781	22485	23234	24033	24890	25815	26819	00
10	19984	20588	21224	21896	22607	23368	24172	25039	25976	26995	10
20	20083	20692	21333	22011	22730	23495	24312	25190	26140	27173	20
30	20183	20796	21444	22128	22854	23628	24455	25344	26306	27354	30
40	20283	20901	21555	22246	23979	23762	24598	25499	26474	27530	40
50	20384	21008	21668	22365	23106	23897	24743	25656	26645	27727	50
M	80	81	82	83	84	85	86	87	88	89	M
00	27917	29130	30484	32019	33789	35881	38441	41740	46387	54331	00
10	28110	29345	30726	32296	34112	36270	38929	42395	47385	56420	10
20	28307	29564	30974	32579	34445	36673	39439	43090	48477	58977	20
30	28507	29787	31226	32870	34788	37096	39973	43830	49684	62274	30
40	28711	30015	31484	33168	35141	37523	40532	44621	51034	66920	40
50	28919	30247	31748	33474	35505	37973	41120	45970	52564	74863	50

To find the Course *and Diſtance by the* Logarithms.

ADmit a *Ship* is at A, in *Latitude* 51 *deg.* 22 *min.* North at *Lundy*, and is to ſail to D in *Latitude* 13 deg. 10 min. which is *Barbadoes*; and the Difference of *Longitude* is 1058 *Leagues*.

Firſt find the Difference of *Latitude* inlarged, as is before directed in the firſt *Problem*, and was found to be 934 $\frac{1}{10}$ *Leagues*.

Now you have given A C the Difference of *Latitude* inlarged, and C D the Difference of *Longitude* 52 deg. 55 min. whereby the *Angles* and *Hypothenuſal* ſhall be found by the Reſolution of a *Right-angled-Triangle*.

Therefore for the Courſe.

As the Difference of *Latitude* inlarged A C *is* 934 $\frac{1}{10}$ parts —— 297057
Is in proportion to the *Radius* 90 deg. —— 10.00000
So is the Difference of *Longitude* in ſuch Parts C D 1058 $\frac{1}{3}$ —— 302448
To the *Tangent* of the *Rhomb*, the *Angle* at A 48 *d.* 33 *m.* —— 1005391

Extend the *Compaſſes* from 934 $\frac{1}{10}$ *Leagues*, the inlarged *Latitude*, to 1058 $\frac{1}{3}$ *Leagues*; the ſame Diſtance will reach from the *Radius* to the *Tangent* of the *Courſe* 48 *deg.* 33 *min.* which is the *Courſe* from *Lundy* to *Barbadoes*, S. W. a little above a quarter of a Point Weſterly.

For the Diſtance.

As the *Sine-Complement* of the *Rhomb*, the *Angle* at D 41 *d.* 27 m. —— 982083
To the Difference of *Latitude* A B 764 *Leagues* —— 288309
So is the *Radius* —— 10.00000
To the *Diſtance* A E 1154 $\frac{2}{10}$ *Leagues* —— 306226

Extend the *Compaſſes* from the *Complement-Sine* of the *Rhomb* 41 deg. 27 min. to the *Sine* of 90 deg. the ſame Extent will reach from the difference of *Latitude* 764 *Leagues*, to the *Diſtance* A E 1154 *Leagues*, which is required.

PROBL. III.

The Latitude *of two Places, and their* Diſtance *given; To find the* Courſe *and the Difference of* Longitude.

ADmit I ſail from the Iſland of *Lundy*, in the *Latitude* 51 deg. 22 min. in the South-weſt Quarter of the *Compaſs*, 1154 $\frac{2}{10}$ *Leagues*; and then find my ſelf in the *Latitude* of 13 deg. 10 min. I would know upon what *Point* of the *Compaſs* I have ſailed, and my difference of *Longitude* to the Weſtward.

The

The Difference of *Latitude* A B is 38 *deg.* 12 *min.* which reduced into *Leagues* is 764 *Leagues.*

For the Course.

As the *Distance* sailed 1154 $\frac{2}{10}$ Leagues A E ——— 306228.
Is in proportion to the *Radius*, 90 deg. ——— 1000000
So is the true Difference of *Latitude* 764 Leagues A B ——— 288309

To the *Sine Compl.* of the *Rhomb* 41 deg. 27 m. the *Angle* at D 982081
That is *S. W. a quarter W.* or *South-West* 3 deg. 33. min. *Westerly*, the *Course* that the *Ship* hath sailed upon.

Extend the *Compasses* from 1154 Leagues the *Distance* to the *Sine* of 90; the same *Distance* will reach from the Difference of *Latitude* 764 Leagues, to 41 deg. 27 min. the *Co-sine* of the *Rhomb*: The *Rhomb* is 48 deg. 33 *min.* that is, 4 *Points* and above a Quarter from the *South-westward* from the *Meridian.*

Secondly, For the Difference *of* Longitude.

Find by the first *Problem* the *Difference* of *Latitude* inlarged, 934 $\frac{1}{10}$ *Leagues.*

Then,

As the *Radius* ——— 10.00000
To the *Diff. Lat.* in *Merid. parts* 934 $\frac{1}{10}$ A C ——— 297057 *Inlarged.*
So is the *Tangent* of the *Rhomb.* 38 deg. 33 min. A. ——— 1005395

To the Difference of *Longitude* in Parts 1058 *Leagues* ——— 302452

Extend the *Compasses* from the *Tang.* 45 deg. to the Difference of *Latitude* inlarged 934 $\frac{1}{10}$ Leagues; the same Extent will reach from the *Tangent* of the *Course* 48 *d.* 33 *m.* to 1058 Leagues.

1058 Leagues converted into Degrees, by dividing by 20, the *Quotient* is 52 deg. 54 min. the Difference of *Longitude* required.

PROBL. IV.

By the Difference of Longitude, *one* Latitude *and the* Course, *To find the other* Latitude *and* Distance *run.*

SUppose I Sail from *Lundy*, in *Latitude* 51 deg. 22 *min. North. S.W.* 3 deg. 33. min. *Westerly*, or *South*, 48 *deg.* 33 *min. Westerly*, until my Difference of *Longitude* be 52 deg. 55 min.

I demand how much I have laid the *Pole*, and how far I am from *Lundy*?

For the Difference of Latitude.

As the *Tangent* of the *Rhomb* 48 deg. 33 min. ——— 1005395
To the Difference of *Longitude* C D 1058 Leagues ——— 302448
So is the *Radius* ——— 10.00000

To the Difference of *Lat.* in *Merid. parts*, Leag. 934 $\frac{2}{10}$ A C — 297053

By

By the Artificial Lines *on the* Scale.

EXtend the *Compaſſes* from *Tangent* 48 *deg.* 33 *min.* to 1058 in the *Line* of Numbers; the ſame Extent will reach from *Tangent* 45 *deg.* to 934 $\frac{5}{10}$ Leagues.

Or, Extend the Compaſſes from *Tang.* 48 deg. 33 min. to *Tangent* 45 deg. the ſame Diſtance will reach from 1058 Leagues, to A C 934 $\frac{5}{10}$ Leagues, as before.

12002
9344
2658

Now the *Meridional parts* anſwering the *Latitude* of 51 *deg.* 20 *min.* are 12002; from it ſubtract 9344 here found, and there remains 2658, which Number I look for in the *Table*, and find the neareſt *viz.* 2657 under 13 *deg.* and 10 *min.* which is the *Latitude* of the ſecond Place where the *Ship* is; and the Difference of *Latitude* is 38 *deg.* 12 min. The *Diſtance* may be found as before, in the ſecond *Problem*.

PROBL. V.

By the Courſe *and* Diſtance, *and one* Latitude; *To find the other* Latitude, *and Difference of* Longitude.

SUppoſe I ſail *S. W.* 3 *deg.* 33 *min. Weſterly*, or *South* 48 *deg.* 33 *min. Weſterly*, 1157 Leagues, and by Obſervation find my ſelf in the *Latitude* of 13 *deg.* 10 *min.* I require the *Latitude* of the Place from whence I came, and the Difference of *Longitude* between the two Places.

For the Difference of Latitude.

As the *Radius* ——— 1000000
To the *Diſtance* ſailed 1154 *Leagues* A E ——— 306220
So is the *Sine-Complement* of the *Courſe* E, 41 *deg.* 27 *min.* —— 982083
To the Difference of *Latitude* 763 $\frac{5}{10}$ or 964 *Leagues* ——— 288303

Extend the *Compaſſes* from the *Sine* of 90 *deg.* to 1154 *Leagues*; the ſame will reach from the *Sine* of 41 *deg.* 27 *min.* to 764 *Leagues*; 764 *Leagues* is 38 *deg.* 12 *min.* the Difference of *Latitude*; which added to 13 *deg.* 10 *min.* the *Latitude* of the laſt Place, the Total is 51 *deg.* 22 *min.* the *Latitude* of the firſt Place required.

The Difference of *Longitude* is found as before in the third *Problem*, ſaying,

As the *Radius*, To the Difference of *Latitude*; *inlarged* 934 $\frac{5}{10}$:
So is the *Tangent* of 48 *deg.* 33 *min*, To the Difference of *Longitude* in *Leagues* 1058, which is 52 *deg.* 55 *min.*

Now to convert the Difference of *Longitude* found in any *Latitude* into *Leagues* of *Departure* or *Diſtance*, do it after this *Example* following.

Suppoſe two Places in one *Parallel* of *Latitude*, as in the *Parallel* of 51 *deg.* 22 *min.* whoſe Difference of *Longitude* is 52 *deg.* 55 *min.* I require the *Diſtance* of thoſe two *Places*.

As the *Radius* ——— 1000000
Is to the *Compl. Sine* of the *Latitude* 51 *deg.* 22 *min.* ——— 979542
So is the Difference of *Longitude* 1058 *Leagues* ——— 302448
To the Diſtance in that *Latitude* 660 *Leagues* $\frac{6}{10}$ ——— 281990

CHAP.

CHAP. VIII.

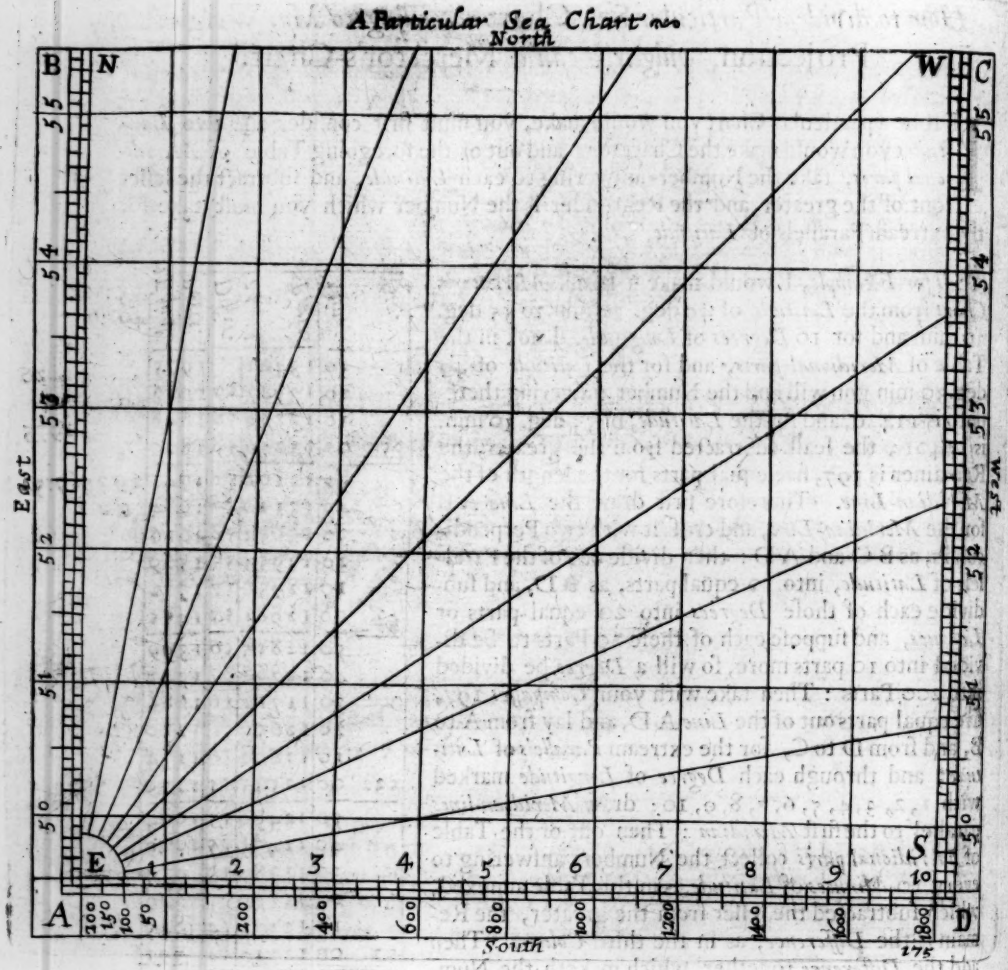
How to divide a Particular Sea-Chart *according to Mr.* Wright's Projection, *vulgarly call'd* Mercator's-Chart.

IF it be a particular Chart you would make, you muſt firſt conſider the two *Latitudes* you would make the Chart for; and out of the foregoing Table of *Meridional parts*, take the Numbers anſwering to each *Latitude*, and ſubtract the leſſer out of the greater, and the Remainder is the Number which you muſt take for the extream Parallels of *Latitude*.

As for Example, I would make a Blank *Mercator's Chart* from the *Latitude* of 49 deg. 30 min. to 55 deg. 30 min. and for 10 *Degrees* of *Longitude*. Look in the Table of *Meridional parts*, and for the *Latitude* of 49 deg. 30 min. you will find the Number anſwering thereunto is 11426, and for the *Latitude*, of 55 deg. 30 min. is 13401; the leaſt ſubtracted from the greater, the Remainer is 197, five equal parts for the length of the *Meridian-Line*. Therefore firſt draw the *Line* A B for the *Meridian-Line*, and croſs it with two Perpendiculars, as B C and A D: then divide one of the Parallels of *Latitude*, into 10 equal parts, as A D, and ſubdivide each of thoſe *Degrees* into 20 equal parts or *Leagues*, and ſuppoſe each of theſe 20 Parts to be divided into 10 parts more, ſo will a *Degree* be divided into 200 Parts: Then take with your *Compaſſes* 197, five equal parts out of the *Line* A D, and lay from A to B, and from D to C, for the extream *Parallels* of *Latitude*; and through each *Degree* of *Longitude* marked with 1, 2, 3, 4, 5, 6, 7, 8, 9, 10; draw *Meridian-lines* parallel to the firſt *Meridian*: Then out of the Table of *Meridional parts* collect the Numbers anſwering to every 10 *Minutes* of *Latitude*, as in this Table annexed, which ſubtracted the leſſer from the greater, the Remain is the *Difference*, as in the third *Column*: Then add the *Difference* together, which maketh the Number in the fourth *Column* in this manner; 52 for the firſt 10 min. and 51 min. added to it, make 103 for 50 min. and 52 added to 103 makes 154 for the Number of *Equal parts* you muſt take out of the *Line* A D for 30 min. from A to 50 deg. of *Latitude*, and lay it on both ſides of the *Chart*, and draw the *Parallel* of 50 *deg.* of *Latitude*: And ſo do of thereſt, as you ſee in this Table. So for 51 *Degrees* the *Number* is 470; take 470 and lay it upwards from A to 51 *Degrees* on both ſides, and draw the *Parallels* of 51 *Degrees* of *Latitude*, and ſo do with the reſt

Deg.	*Min.*	*Parts.*	*Merid.*	*Differ.*	*Equal Parts.*
	30	13401		1975	
	20	13342	59	1916	
	10	13284	58	1858	
55	00	13226	58	1800	
	50	13168	58	1742	
	40	13110	58	1684	
	30	13052	58	1626	
	20	12955	57	1569	
	10	12938	57	1512	
54	00	12881	57	1455	
	50	12815	56	1399	
	40	12768	57	1342	
	30	12712	56	1286	
	20	12656	56	1230	
	10	12600	56	1174	
53	00	12545	55	1119	
	50	12490	55	1064	
	40	12435	55	1009	
	30	12380	55	954	
	20	12325	55	899	
	10	12271	54	845	
52	00	12217	54	791	
	50	12163	54	737	
	40	12109	54	683	
	30	12055	54	629	
	20	12002	53	576	
	10	11949	53	523	
51	00	11896	53	470	
	50	11842	54	416	
	40	11790	52	364	
	30	11737	53	311	
	20	11685	52	259	
	10	11633	52	207	
50	00	11581	52	155	
	50	11529	52	103	
	40	11478	51	52	
	30	11426	52		

55: 30
49
13401
11426
49
1975
x
1975(9:52
20



CHAP. IX.

The Projection of the Meridian-Line *by* Geometry, *and how to make a* Scale *of* Leagues *for to measure* Distances *in any* Latitude.

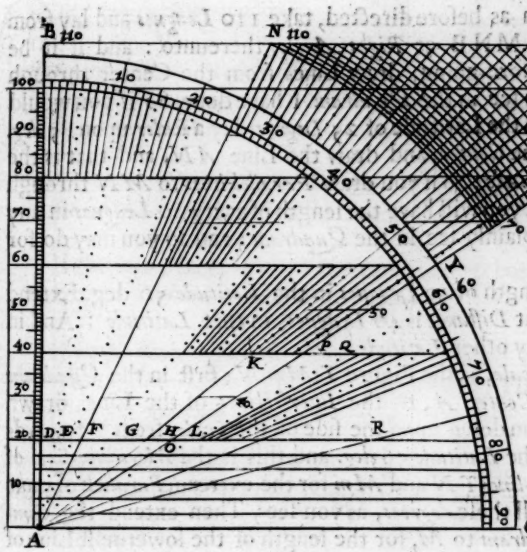
THE Projection is the ground-work of Mr. *Wright*'s Table of *Latitudes*, in his Book called, *The Correction of Errors in Navigation*, where he sheweth how to make it, and hath also made a Table by the continual addition of the *Secants* of every *Minute*, which shews how much you are to lengthen the *Degrees* of *Latitude* in your *Chart*, that so there may be a true proportion between the *Degrees*

Degrees of *Longitude* and *Latitude* in all Places. Which *Table* I have abridged, by reducing it into *Leagues* and *Tenth parts*, as hath been ſhewed before. We will here ſhew you how to do the ſame by *Geometry*, that is, how to make a *Meridian-Line* anſwerable to any *Line* of *Longitudes*, and alſo to make a Scale of 100 *Leagues* to meaſure a Diſtance in any *Latitude*.

Firſt, Make the *Quadrant* A B C, of what largeneſs you pleaſe, and divide the Limb thereof into 90 *Degrees*, and number them from B towards C; Then divide the Side of the *Quadrant* in 5 *Equal parts*, which are five *Degrees* of the *Æquinoctial*. Then divide the firſt *Degree* from the *Center*, as A D, into 6 *Equal parts*, and through them draw *Parallel-lines* to A C: You may divide each of the other four *Degrees* from D to B into 20 *Equal parts*, which are *Leagues*, and ſo you may number them as you ſee, from 10 to 100: So the whole *Line* A B will be your *Radius*, and the length of 110 *Leagues*, or five *Degrees* and a half of *Longitude* of your *Chart*.

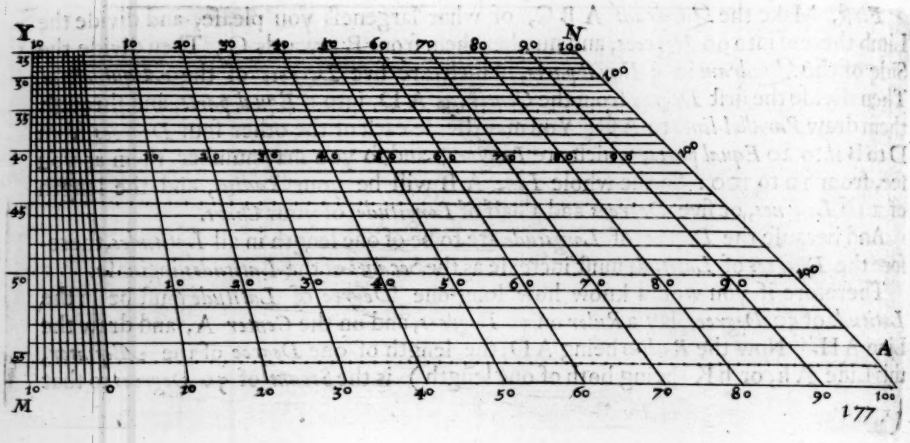
And becauſe the *Degrees* of *Longitude* are to be of one length in all *Latitudes*, therefore the *Degrees* of *Latitude* muſt increaſe as the *Secants* of the *Latitudes* increaſe.

Therefore if you would know how long one *Degree* of *Latitude* muſt be in the *Latitude* of 50 *Degrees*, lay a *Ruler* on 50 *Degrees*, and on the *Center* A, and draw the Line A H. Now the *Radius* being A D, the length of one *Degree* of the *Æquator*, this Line A h, or h K (being both of one length) is the *Secant* of 50 *Degrees* to that



Radius, and muſt be the length of one *Degree* of *Latitude* in a Chart from 50 *Degrees* to 51 *Degrees*, and ſo the Line A E which is the *Secant* of 20 *Degrees*, is the length of one *Degree* of the *Meridian-line* in the *Latitude* of 20 *Degrees*, and ſo for any other *Latitude*.

A Scale *of* Leagues *from the* Latitude *of* 25 Degrees, *to the* Latitude *of* 56 Degrees.



How to make the Scale *of* Leagues.

THE *Quadrant* being drawn as before directed, take 110 *Leagues* and lay from A to B, and draw the Line MNB at *Right Angles* thereunto: and if it be for a particular Chart, as that before-going, draw Lines from the Center through every degree of Latitude; as you ſee in the *Quadrant* I have done. So if you would know the length of 100 *Leagues* in the Latitude of 25 *Degrees* lay a *Ruler* upon 25 *deg.* in the *Arch* of the *Quadrant* and the *Center*, and draw the Line *AN*, and that is the length of 110 *Leagues* in that *Latitude*: So if you draw *Parallel-lines* to *MN* through every 10 *Leagues* in the Side AB, you will have the length of every 10 *Leagues* in any degree of *Latitude*, as you may plainly ſee in the *Quadrant*; and ſo you may do for every *League* if you pleaſe.

Suppoſe you would know the length of 40 *Leagues* in the *Latitude* 50 deg. Extend the *Compaſſes* from A to K, and that *Diſtance* is 40 *Leagues*, in that *Latitude*: And in like manner work by the reſt in any other *Latitude*.

If you would make this into a *Scale*, as the Figure *Y Mm N*; firſt in the *Quadrant* extend your *Compaſſes* from the *Center A*, to the *Interſections* of the Lines drawn through every degree and lay them down upon the ſide of the *Scale*, from Y towards M, from the *Latitude* 25 *deg.* to the *Latitude* 56 *deg.* and this is the *Meridian-line* of your *Scale*, then draw the *Parallel-lines Y N* and *Mm* for the extream *Parallels* of your *Scale*; and draw *Parallel-lines* to all theſe *degrees*, as you ſee; Then extend the *Compaſſes* from the *Center* of the *Quadrant* to *M*, for the length of the lowermoſt Line of your *Scale* Mm 110 *Leagues*, and extend the Compaſſes from the *Centre* of the *Quadrant* to *N*, which is the length of 110 *Leagues* in the *Lat.* of 25 *deg.* and it is the length of the uppermoſt Line *Y N* of your *Scale*; and draw *Nm* the outſide line of your *Scale*: So take every 10 *Leagues* from the *Center* A, in the Line *AM*, in *Lat.* 56 *deg.* and divide the lowermoſt Line of the *Scale*; and the like do in the *Lat.* of 25, for to divide the uppermoſt Line of the *Scale*; and draw Lines through each of them, which will divide all the reſt of the *Parallel-lines* in each *Latitude* into 10 *Leagues* and number them as you ſee in the *Scale*; and divide the firſt 10 *Leagues* next the *Meridian-line* of the *Scale* into 10 Equal parts below and above, and draw Lines through each of the *Diviſions*: ſo have you divided your *Scale* to every degree of *Latitude* into *Leagues*; which will meaſure the diſtance of any two places in the true *Chart*, which are near the ſame *Parallel* of *Latitude*.

CHAP.

CHAP. X.

Sailing by a Great Circle.

WE will now ſhew you the way of Sailing by the *Arch* of a *Great Circle*, which is the neareſt way of *Sailing* of all others, if a man may have *Winds*, to keep near the *Arch* that goes over the two Places propounded; and that there are no *Rocks*, nor *Sands*, nor *Iſlands*, that lye in the way.

And this *Sailing* by the *Arch* of a *Great Circle*, will prove a great advantage when your *Courſe* lies near *Eaſt* and *Weſt*; for *Sailing Eaſt* or *Weſt*, you truſt altogether to the *Dead Reckoning* (by the two former ways of *Sailing*) but by this way you help your ſelf by altering your *Latitude* ſeveral *Degrees*, by which you may rectifie your *Account*. *Plain Sailing*, Mercator's.

For Example, Admit you were to ſail from *Avero* on the *Coaſt* of *Portugal*, to the *Bay* on the back ſide of *Aquamacke* near *Virginia*, which lye both near the *Latitude* of 40 *Degrees*; and ſuppoſe the difference of *Longitude* between theſe two Places be 70 *Degrees*: The *Diſtance* of the two Places *Eaſt* and *Weſt* is 53 *deg.* and a half and ſomething more; but the *Diſtance* in the *Arch* of a *Great Circle* is but 52 *deg.* and a little more; that is, 1 *deg.* and about half leſs, which is but a little benefit to this, which is the chiefeſt. That in ſailing between two ſuch places by the *Arch* of a *Great Circle*, you will in the firſt half of the way raiſe the *Pole* 5 *deg.* 41 *min.* and then in the other half depreſs the *Pole* as much; ſo that in the whole *Voyage* you will alter your *Latitude*, 11 *deg.* 22 *min.* by ſeveral *Courſes*; by which you may rectify your *Dead Reckoning*, which you cannot do in ſailing upon a *Parallel* of *Eaſt* and *Weſt*; So that you ſee it is the beſt way of ſailing, as well as the neareſt, eſpecially in ſuch *Voyages*, if the *Wind* favour you.

This Arch *of a* Great Circle *over two places in* Latitude 40 *deg. and Diff. of* Long. 70 *d. is the Line* P. W. *in the* Diagram *of the* 13 Chap. *of part of the* Globe *in* Plano.

If the two Places lye under the *Æquinoctial* or under the ſame *Meridian*, The *Diſtance* between them is thus found.

If the two Places have no *Latitude* (being both under the *Æquator*) the *Longitude* is the *Diſtance* in *degrees* and *minutes*.

If both Places agreeing in *Longitude*, have *Latitude* alſo of like denomination, (both *Latitudes Northerly*, or both *Southerly*) then ſubtract the leſſer out of the greater, the Remain is the *Diſtance*.

But if both Places in one *Meridian*, have one *Northerly Latitude*, and the other *Southerly Latitude*, add them together, the Sum is the *Diſtance* in *degrees*.

CHAP. XI.

Two known Places, one of them having no Latitude: *The other having* Latitude *and* Difference *of* Longitude; *To find*

1 *Their* Diſtance *in a* Great Circle.
2 *The* Direct Poſition *of the firſt Place from the Second.*
3 *And the Second Place from the Firſt.*

The Firſt Scituation.

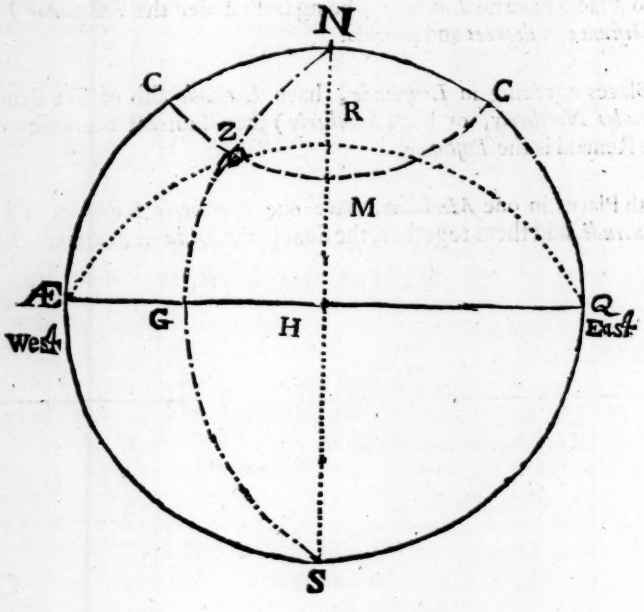
FFrſt, If any two Places being propoſed, the one under the *Æquinoctial*, the other being in any other *Latitude* given, either *North* or *South*, and the Difference of *Longitude* of the Places being known; you may find the three things before ſpoken of, by the following directions.

We call the *Angles* which the *Arch* of a Great *Circle* makes with the *Meridians* of thoſe Places, the *Angles* of *Poſition*.

Now in the following *Diagram*, let Æ be the Entrance of the great *River* of *Amazons*, under the *Æquator*; A Q the *Æquator*, and let C repreſent the Iſland of *Lundy*, lying in *Latitude*, 51 deg. 22 min. *Northerly*, and C Q the *Meridian* thereof: and ſuppoſe the Difference of *Longitude* A Q to be 41 deg. 22 min.

The Stereographick Projection.

With a *Chord* of 60 deg. deſcribe the *Circle* Æ N Q S, and draw the *Æquinoctial* Æ Q, croſſing it at *Right Angles* with the Line *N S N*, being the *North-pole*, and *S* the *South*. Let Æ repreſent the River of the *Amazons*, then by the Line of natural *Tangents*, lay off the *Tangent* of half 48 d. 38 m. the *Compl.* of the *Diff. Long.* (*viz. Tang.* 24 d. 19 m. or 24 d. $\frac{1}{4}$) from H to G, and deſcribe the *Meridian* N G S. Lay off the *Chord* of 51 d. 22 m. from Æ and Q to Æ and C, and the *Tangent* of half 5 d. 22 m. (*viz.* 25 d. 41 m.) from H to M, and deſcribe the *Parallel* Z M C, cutting the *Meridian* N G S in the Point *Z*, which repreſents *Lundy*: then the *Arch* Æ Z Q, paſſing by the point Z, which is the *Arch* of a great *Circle* paſſing from the *Amazons* to *Lundy*, and Æ Z is the *Diſtance* in the *Arch* from the *Amazons* to *Lundy*; and the *Angle* N Æ Z is the *Angle* of *Poſition* from the *Amazons* to *Lundy*, and N Z Æ is the *Angle* of *Poſition* from *Lundy* to the *Amazons*.



By

By the Logarithms.

IN the *Quadrantal Triangle* Æ Z N, there is given N Z, and the Angle Z N Æ, to find Æ Z, and the *Angles* Z Æ N and Æ Z N; Or in the adjacent *Right-angled-Triangle* Æ Z G (*Right-Angled* at G) there is given G Z the *Complement* of N Z to 90 deg. and Æ G the meaſure of Æ N Z, to find Æ Z and the *Angles* G Æ Z (and the *Complement* of N Z Æ to 180 deg.) and G Æ Z the *Complement* of Z Æ N to 90 deg.

For the Diſtance *in the* Arch Æ Z.

As *Radius* is to the *Co-ſine* of difference of *Longitude* 41 d. 22 m. —— 987534
So is *Co-ſine* of the *Latitude* 51 deg. 22 min. —————— 979541
To the *Co-ſine* of the *Diſtance* 62 deg. 04 min. —————— 967075

Which converted into *Leagues*, is 1237 ⅓ the neareſt *Diſtance* between thoſe two Places.

For the Angle *of* Poſition *from the* Amazons *towards* Lundy, G Æ Z *the Complement of* N Æ Z *to* 90 *deg.*

As the *Radius*, to the *Sine* of the Diff. of *Longitude* 41 d. 22 m. —— 982011
So is the *Co-Tangent* of the *Latitude* 51 deg. 22 min. —————— 990267
To the *Co-Tangent* of the *Angle* —————— 972278

For the Angle *of Poſition* G Æ Z, 62 *deg.* 10 *min. whoſe* Complement *to* 90 *deg. is* 27 *deg.*, 50 *min. the* Angle N Æ Z *from the* Amazons *to* Lundy.

As *Radius* 90, is to *Sine* of the *Latitude* 51 d. 22 m. Q C —— 989273
So is *Co-Tangent* of Diff. of *Longitude* 41 deg. 22 min. A Q —— 1c05522
To the *Co-Tangent* of the *Angle* Æ Z G 48 deg. 26 min. —————— 994795

Whoſe *Complement* to 180 deg. is 131 deg. 34 min. the *Angle* Æ Z N.

PROBL. II.

How to find the Great Circle's *greateſt* Latitude *North or South, or the* Obliquity.

NOte, Without the knowledge of the true Quantity of the *Obliquity* or *Latitude* of that *Great Circle*, which will paſs directly over the *Places* propounded, there can be no compleat Demonſtration, much leſs *Arithmetical Calculation* of things pertaining thereunto; therefore it is needful that the true Quantity of each *Great Circle's Obliquity* be diligently found to exact certainty: which to do, in ſome Caſes is very eaſie, and in ſome again more difficult.

Therefore I will propound *Rules* for the ſeveral *Scituations* following, except thoſe that are ſcituate under the *Æquator*, or under the ſame *Meridian*.

If one Place be under the *Æquator* and hath no *Latitude*, and the other hath any Quantity of *Latitude*, and the Difference of *Longitude* being leſs than 90 deg. as before 41 deg. 22 min. it is eaſily found, thus:

The

The greateſt *Obliquity* in the foregoing *Diagram* is H R, or the *Angle* G Æ Z.

As the *Sine* of the found *Diſtance* 62 deg. 4 min. ——— 994620
Is to the *Sine* of the *Latitude* 51 deg. 22 min. ——— 1989273

So is the *Radius* (added to the laſt Number) ——
To the *Sine* of the greateſt *Obliquity* 62 d. 09 m. ——— 994653

So 62 *deg.* 9 *min.* is the greateſt *Obliquity* or *Latitude* from the *Æquator*, of that *Great Circle* extended over thoſe two Places.

But if the Difference of *Longitude* be 90 deg. as Æ H, and one of the Places have no *Latitude*, and the other have any quantity of *Latitude*; then it is evident to reaſon, as in the foregoing *Diagram* may appear, that the ſecond Place is ſcituate in the point of the greateſt *Obliquity*, which is never above 90 deg. as H N; and the other Place being in the Point of *Interſection* of the ſaid *Great Circle* with the *Æquator*.

For Note,

That every *Great Circle* that paſſeth over any two Places propounded, cuts the *Æquator* in two oppoſite *Points* 180 *deg.* from each other, as the *Ecliptick Line* doth in the two *Points* of *Aries* and *Libra*, whoſe greateſt *Obliquity* 23 *deg.* 30 *min.* the *Sun's* greateſt *Declination.*

Now if one Place have no *Latitude*, 00 *deg.* 00 *min.* and the other have any quantity of *Latitude*, the Difference of *Longitude* being more than 90 *deg.* to find the *Obliquity* of the *Great Circle* paſſing over thoſe Places; Proceed thus,

As admit one Place *Latitude*, 00 *deg.* 00 *min.* and the other 51 *deg.* 22 *min. Difference* of *Longitude* 138 *deg.* 38 *min.* Diſtance betwixt them is near 117 *deg.* 56 *min.* Therefore take the *Diſtance* out of 180, and there remains 62 *deg.* 04 *min.*

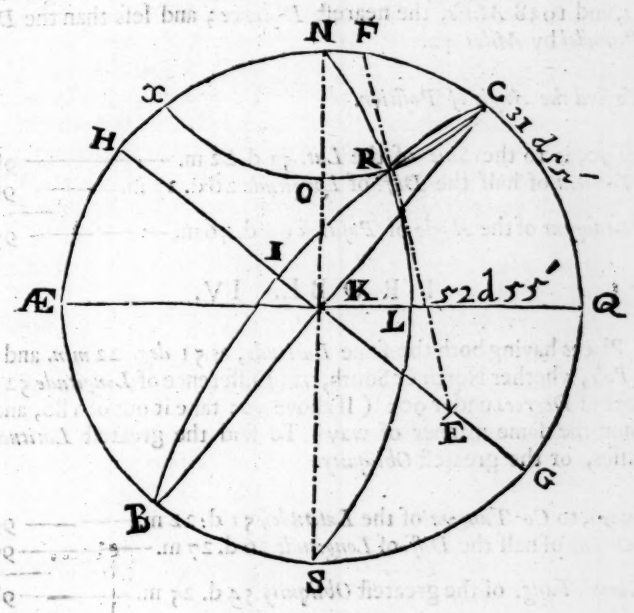
As the *Sine* of the *Remainer* 62 *deg.* 04 *min.* ——— 994620
Is to the *Sine* of the *Latitude* 51 *deg.* 22 *min.* ——— 989273
So is *Radius* ——— 10
To the *Sine* of the greateſt *Obliquity* 62 *deg.* 09 *min.* ——— 994653

As in the former *Example*; And ſo you may work for any *Queſtions* of this nature.

The ſecond Scituation.

SEcondly, There may be two Places both ſcituated in any Parallel of *Latitude*, betwixt the *Artick* and *Antartick Poles*, differing only in *Longitude.*

PROBL.



PROBL. III.

Admit there be two Places both in the Latitude *of* 51 *deg.* 22 *min. and their Difference of* Longitude *be* 52 *deg.* 55 *min.*

1. *To find the neareſt* Diſtance *of thoſe two Places.*
2. *The* Direct Poſition *of the one Place from the other.*

The Stereographick Projection.

HAving drawn the *Circle* NQSÆ and the Lines NS and ÆQ, take off the Line of *Chords* the *Latitude* of the Place 51 *deg.* 22 *min.* and lay from Æ to X, and from Q to C; and take of the half *Tangents* the ſame *Latitude*, and lay from K to O; and through theſe three Points draw the *Parallel* of *Latitude* XOC; the *Complement* of the Difference of *Longitude* laid from R to L by the half *Tangents* draw the *Meridian-Circle* NLS, the ſecond place is at R, and firſt at C; Therefore draw the *Circle* from C through R to B, and meaſure KI on the half *Tangents*, and you will find it 21 *deg.* and a quarter, whoſe *Complement* to 90 *deg.* is 68 *deg.* three quarters the *Angle* of *Poſition* NCR. Now from the half *Tangents* take 68 *deg.* and three quarters and lay it from the *Center* K to E, and from E draw through the Point of *Interſection* at R the prickt Line ERF; and meaſure CF on the Line of *Chords*, and you will find it 32 *deg.* and a quarter for the *Great Circles* Diſtance.

In the Seventh *Problem* of ſailing by *Mercator's Chart*, you may ſee there was required the *Diſtance* of theſe two Places meaſured in the *Parallel*, and found to be 660 $\frac{1}{10}$: But here is required the neareſt *Diſtance* in the *Arch* of a *Great Circle*: Work thus by the Tables of *Logarithms*.

For the Diſtance,

As the *Radius*, is to the *Sine Compl.* of the *Lat.* 38 d. 38 m. —— 979541
So is the *Sine* of half the *Diff.* of *Longit.* 26 d. 27 m. —— —— 964876

To the *Sine* of half the *Diſtance* 16 deg. 09 min. —— —— 944417

Which doubled is 32 *deg.* 18 *min.* and this converted into *Leagues* and *Miles*, is 645 *Leagues*, and 1938 *Miles*, the neareſt *Diſtance*; and leſs than the *Diſtance* meaſured in a *Parallel* by *Miles* 42.

To find the Angle of Poſition.

As *Radius* 90, is to the *Sine* of the *Lat.* 51 d. 22 m. —— 989273
So is the *Tangent* of half the *Diff.* of *Longitude* 26 d. 27 m. —— 969678

To the *Co-tangent* of the *Angle* of *Poſition* 68 d. 46 m. —— 958951

PROBL. IV.

TWO Places having both the ſame *Latitude*, as 51 *deg.* 22 *min.* and towards the ſame *Pole*, whether North or South, and Difference of *Longitude* 52 *deg.* 55 *min.* or any number of *Degrees* under 90: (If above 90: take it out of 180, and work with the Remainer the ſame manner of way) To find the greateſt *Latitude* by which the *Arch* paſſes, or the greateſt *Obliquity*.

As *Radius* 90, to *Co-Tangent* of the *Latitude*, 51 d. 22 m. —— 990267
So is the *Co-ſine* of half the *Diff.* of *Longitude* 26 d. 27 m. —— 995197

To the *Compl. Tang.* of the greateſt *Obliquity* 54 d. 25 m. —— 985464

So that the greateſt *Obliquity* is 54 *deg.* 25 *min.* And the ſame Proportion will hold for any Queſtion of this nature.

PROBL. V.

The Third Scituation.

One Place having North Latitude, *and the other Place having South* Latitude, *of different Quantities, and the* Difference *of their* Longitudes *leſs than* 90. *As admit one Place having North* Latitude, *as* Lundy, 51 deg. 22 min. *the other South* Latitude, *as the* Rio de la Plata, 35 deg. 00 min. Difference *of* Longitude *betwixt them* 45 deg. 55 min. *I demand the* Diſtance, *the* Angle *of* Poſition, *and the greateſt* Latitude *or* Obliquity *of the* Great Circle *that paſſeth over theſe two Places.*

AFter you have deſcribed the outward *Meridian* NESA, and the *Lines* NS and AE, take from the *Line* of *Chords* the *Latitude* 51 deg. 22 min. and lay it from E to P, and draw the *Line* PCO, and HCM at *Right Angles* to PO, take off the *Line* of half *Tangents*, the *Complement* of the *Difference* of *Longitude*, to 90 deg. *viz.* 44 deg. and lay it from E to F, and draw the *Meridian-Circle* NFS, whereon lay the *Latitude*, of *Rio de la Plata* 35 deg. from F to R, by taking 35 out of the *Line* of

Chords

Chords, and laying it from *E* to 35, and the half *Tangent* of 46 *deg.* from *C* to *Pole*, and draw the prickt *Line Pole* 35, which cuts the *Circle N F S* in *R*, which is *Rio de la Plata*: and through *R* draw the *Circle P R O*, and measure *C N* on the half *Tangents*, you will find it to be 54 *deg.* to which adding 90 *deg.* makes the *Angle* of *Position N P R* 144 *deg.* Then take the half *Tangent* of 36 *deg.* and lay from *C* to *K*, and draw the prickt Line from *K* through *R*, and it will cut the *Circle N E S A* at *T*; therefore measure *T P* on the Line of *Chords*, and that is the measure of *R P* 95 *deg.* $\frac{1}{4}$ for the *Distance*, the greatest *Latitude* or *Obliquity* is *V L W*, which touches the *Parallel* of 68 *deg.* $\frac{1}{4}$, the greatest *Circle P R O*.

By the Logarithms; *To find the* Distance *in the* Arch.

As *Radius* to the *Co-sine* of *Differ.* of *Longitude* 45 d. 55 m.	984242
So is the *Co-Tangent* of the greater *Latitude* 51 deg. 22 min.	990267
To the *Tangent* of the first *Arch* 29 deg. 5 min.	974509

The less *Latitude* 35 deg. and 90 deg. makes 125 deg. Take the first *Arch* 29 deg. 5 min. therefrom, and there remains 95 deg. 55 min. which is the second *Arch*.

Then,

As *Co-sine* of the first *Arch*, 29 deg. 5 min.			994146
Is to the *Co-sine* of the second *Arch* 05 deg. 55 min.			901318
So is the *Sine* of the greater *Latitude* 51 deg. 22 min.			989273
Out of	180 d. 00 m.	To the *Co-sine* of 95 d. 17 m.	1890591 *Sum*
Take	84 43		
And there remains	95 17	The *Distance*	895445

To find the Angles *of* Position, N P R *and* P R N, *in the* Oblique Triangle N P R.

	Co. Arith.
As *Sine* P R the *Distance* in the *Arch* 95 d. 17 m.	0.00185
To *Sine* P N R the *Diff.* of *Longitude* 45 55	9.856 2
So is *Sine* N R the lesser *Latitude* 35 d. and 90 d. — 125 d. 00 m.	9.91336
To *Sine* N P R 143 d 47 m. which is the *Angle* of *Position* from *Lundy* to *Rio de la Plata.*	19.77153

Then,

	Co. Arith.
As *Sine* P R the *Distance* in the *Great Circle* 95 d. 17. m.	0.00185
To *Sine* P N R the *Difference* of *Longitude*, 45 55	9.85632
So is *Sine* N P the *Compl.* greater *Latitude*, 38 38	9.79542
To *Sine* N R P 26 d. 16 m. is the *Angle* of *Position* from *Rio de la Plata* to *Lundy*.	19.65359

To find the Obliquity, *or the greatest* Latitude *by which the* Arch *passes.*

As *Radius* to the *Co-sine* of the greater *Latitude*, 51 d. 22 m.	979542
So is the *Sine* of the greater *Angle* of *Position* 143 47	977147
To the *Co-Sine* of the greatest *Latitude*, which is 68 d. 22 m.	9.56689

The Fourth Scituation.

PROBL. VII.

The Latitude *of two Places both in one* Hemiſphere *being given, together with the* Difference *of* Longitude ; *To find,*

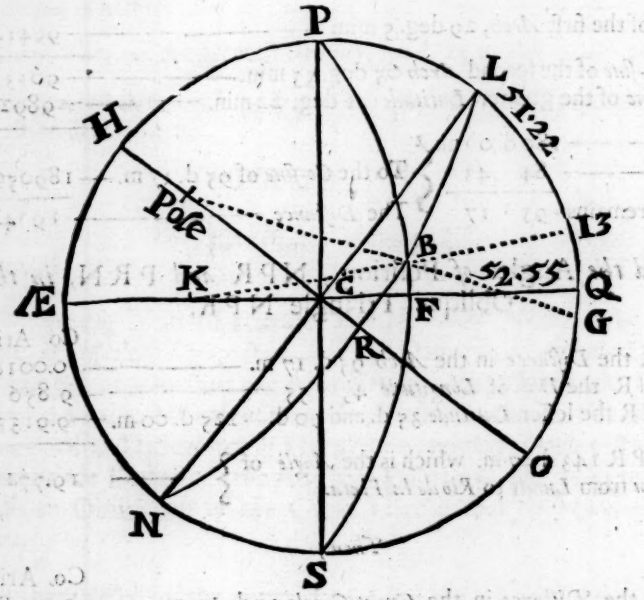
First, *The* Diſtance *in the* Arch *of a* Great Circle.

Secondly, *The* Angle *of* Poſition *from the firſt Place to the ſecond.* And,

Thirdly, *From the ſecond Place to the firſt.* And,

Fourthly, *The* Circles *greateſt* Obliquity *that paſſeth over thoſe two Places.*

ADmit L H be *Lundy* in the *Latitude*, 51 deg. 22 min. and *Longitude* 25 deg. 52 min. (from the Weſt end of St. *Michaels*) and B the *Barbadoes* in the *Latitude* 13 deg. 10 min. and *Longitude* 332 deg. 57 min. and *Diff.* of *Long.* 52 d. 55 m.



Lay down firſt the *Latitude* 51 deg. 22 min. from Q to L; ſecondly the *Difference* of *Longitude* Q F 52 deg. 55 min. and draw the *Meridian-circle* P F S; then lay down the *Latitude* of *Barbadoes* from Q to 13, and take of the half *Tangent Line* Q F 52 deg. 55 min. and lay from C to K, and draw the prick'd *Line*, which will cut the *Meridian* P F S in B, the *Latitude* of *Barbadoes*, 13 deg. 10 min. Through B draw the *Circle* L B N, ſo the *Angle* of *Poſition* from *Lundy* to the *Barbadoes* is B L P, whoſe meaſure is H 112; then take off the *Line* of half *Tangents*, 68 deg. and lay it from C to *Pole*, and draw the *Line* from *Pole* through B, and it will cut the *Limb* in G: Therefore meaſure G L on the *Line* of *Chords*, you have 57 deg. for the *Diſtance*.

To

To find the Diſtance *by the* Logarithms.

As the *Radius*, is to the *Co-Sine* of the *Diff.* of *Longit.* 52 d. 55 m. — 978030
So is the *Co-tang.* of the greater *Latitude* 51 deg. 22 min. — 990267

To the *Tangent* of the firſt *Arch* 25 deg. 44 min. — 968197

Take 25 deg. 44 min. from 76 deg. 50 min. the *Complement* of 13 deg. 10 min. the leſs *Latitude*, and the Remain is 51 deg. 6 min. the ſecond *Arch*.

As the *Co-Sine* of the firſt *Arch* 25 deg. 44 min. — 995464
Is to the *Co-ſine* of the ſecond *Arch* 51 d. 06 m. — 979793 } *To find the Diſtance.*
So is the *Sine* of the greater *Latitude* 51 d. 22 m. — 989273

1969066

To the *Co-ſine* of the *Diſtance* 57 d. 00 m. — 973602

Which is the *Diſtance* in the *Arch* of a *Great Circle*, being 17 *Leagues* leſs than by *Mercator's Chart*, and leſs by 166 *Leagues* than by the *Rhomb* on the *Plain Chart*; which confirms this to be the neareſt of all ways of Sailing betwixt any two Places.

To find the Angle *of* Poſition *for* Lundy *to* Barbadoes.

As the *Sine* of the *Diſtance* 57 deg. 00 min. — 992359

Is to the *Sine* of the *Difference* of *Longitude* 52 deg. 55 min. — 990187
So is the *Co-Sine* of the leſs *Latitude* 13 deg. 10 min. — 998843

1989030

To the *Sine* of the *Angle* of *Poſition* — 996671

Which is 112 deg. 09 min.

To find the Angle *of* Poſition *from* Barbadoes *to* Lundy.

As the *Sine* of the *Diſtance* 57 deg. 00 min. — 992359

To the *Sine* of the *Difference* of *Longitude* 52 deg. 55 min. — 990187
So is the *Co-ſine* of the greateſt *Latitude* 51 d. 22 m. — 979541

1969728

To *Sine* of the *Angle* of *Poſition* 36 d. 26 m. — 977369

To find the Obliquity.

As *Radius* to *Co-ſine* of leſs *Latitude* 13 deg. 10 min. — 998843
So is the *Sine* of the leſſer *Angle* of *Poſition* 36 deg. 26 min. — 977370

To the *Co-ſine* of the greateſt *Obliquity* 54 deg. 40 min. — 976213

CHAP.

CHAP. XII.

How to deſcribe the Globe *in* Plano, *by the* Mathematical SCALE.

THeſe, and all other Queſtions of this nature, concerning the Reſolution of any *Spherical Triangle*, may very eaſily be performed by the *Globe*: But becauſe the *Globe* is a chargeable Inſtrument, and ſo every one cannot have it, therefore ſeveral Men, have invented divers ways to project the *Globe* upon a *Plain*, as Mr. *Gunter* hath them in his Book of the *Sector*.

The fitteſt for this purpoſe will be that of *Gemma Friſius*, which is moſt uſed in the large *Mapps* of the World, the *Projection*, whereof is as followeth.

Firſt, By the *Chord* of 60 deg. deſcribe the *Circle* Æ N E S, and by the *Chord* of 90 deg. divide it into four parts as Æ E for the *Æquator*, and N S for the primary *Meridian*: Then by taking off every 5 deg. of the *Chord*, you may divide each *Quadrant*, and number them as in the *Figure*: Then take off your *Line* of half *Tangents* in your *Scale* every 5 *deg.* and lay them from the *Center* C on the four *Quadrants*, and number them as they are in the *Figure*; ſo ſhall you divide the *Diameters* Æ E the *Æquinoctial*, & N S the *Meridian*.

Now you have divided the *Diameters*, they will guide you in the drawing of the *Meridians* from *Pole* N to *Pole* S, which are *Circles*; as likewiſe are the *Parallels* of *Latitude*.

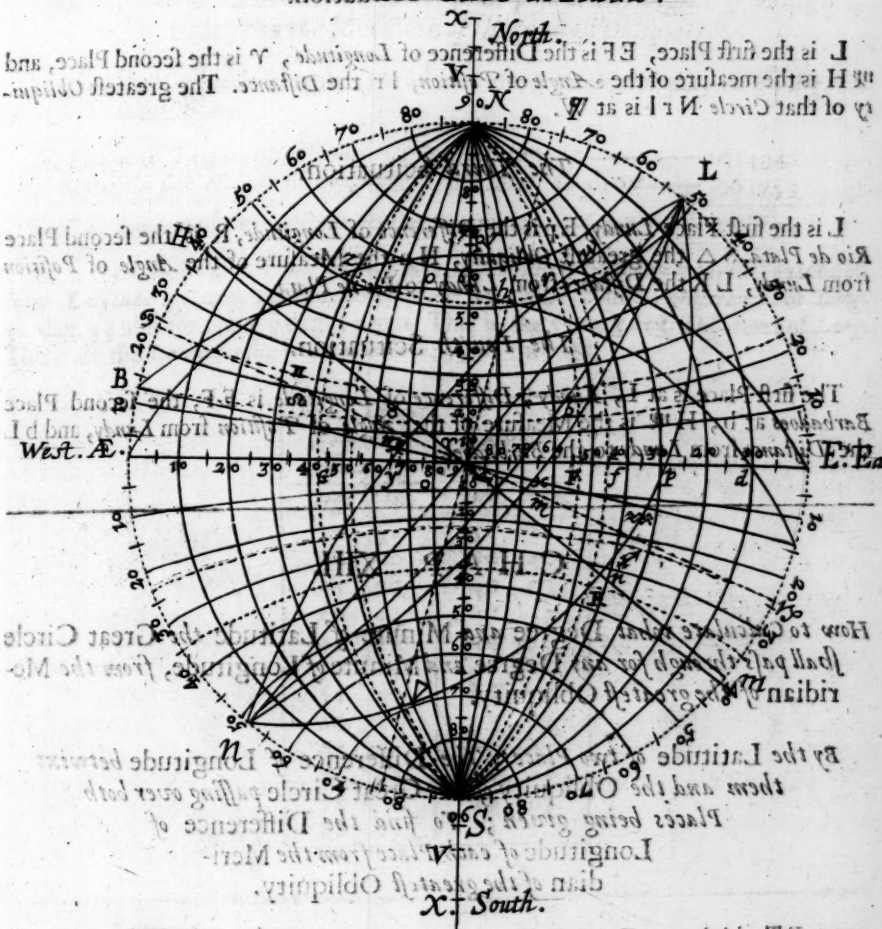
How to find the Centers *of the* Meridian-circles.

You may find the *Centers* in the *Diameter* Æ E, if you extend the Compaſſes to the *Secants* of every 10 deg. and with that *Diſtance* put one *Point* at 10 deg. in the *Semidiameter* Æ C, and the other *Point* will fall in E C, and be the *Center* of the *Meridian* of the firſt 10 deg. from Æ, and do the like for any other degree, continuing the *Diameter* when need ſhall require it.

How to find the Centers *of the* Parallels *of* Latitude.

For the *Parallels* of *Latitude*, Take the *Complement* of the *Latitude* from your *Line* of *Tangents*, put one *Point* in the degree of *Latitude*, the other will ſtand in the *Center*.

The Globe in Plano.



190.

For EXAMPLE.

If you will draw the Parallel of *Latitude* for 60 *deg.* take off the *Tangent-line* of your *Scale* 30 *deg.* the *Compl.* of 60 *deg.* of *Latitude*, and the other will fall upon V the Center of the Parallel of 60 *deg.* in the *Semidiameter* N S, continued beyond the *Circle.*

So, Take the *Tangent* of 40 *deg.* and it will draw the Parallel of 50 *deg.* whose *Center* is at X, and so do in drawing all Parallels of *Latitude.*

The Four Scituations *that are in the* Globe.

The First Scituation.

Æ is the *Point* for the Mouth of the River of *Amazons*, Z *Lundy*, C R the *Obliquity*, E the other *Point* of *Intersection* with the *Æquator*, N R the meaſure of the *Angle* of *Poſition* from *Amazons* to *Lundy*, Æ Z the *Diſtance* from *Amazons* to *Lundy.*

The

The Second Situation.

L is the first Place, E F is the Difference of *Longitude*, ♈ is the second Place, and ♍ H is the measure of the *Angle* of *Position*, l r the *Distance*. The greatest *Obliquity* of that *Circle* N r l is at W.

The Third Situation.

L is the first Place *Lundy*, E p is the *Difference* of *Longitude*, R is the second Place *Rio de Plata*, S △ the greatest *Obliquity*, H n the Measure of the *Angle* of *Position* from *Lundy*, L R the *Distance* from *Lundy* to *Rio de Plata*.

The Fourth Situation.

The first Place is at L, *Lundy*; *Difference* of *Longitude* is E F, the second Place *Barbadoes* at b; H ♍ is the Measure of the *Angle* of *Position* from *Lundy*, and b L the *Distance* from *Lundy* to the *Barbadoes*.

CHAP. XIII.

How to Calculate what Degree *and* Minute *of* Latitude *the* Great Circle *shall pass through for any* Degree *and* Minute *of* Longitude, *from the* Meridian *of the greatest* Obliquity.

By the Latitude *of two Places, the* Difference *of* Longitude *betwixt them and the* Obliquity *of the* Great Circle *passing over both Places being given; To find the* Difference *of* Longitude *of each Place from the* Meridian *of the greatest* Obliquity.

LET this be our *Example*. *Lundy* in *North Latitude* 51 deg. 22 min. and *Barbadoes* in *North Latitude* 13 deg. 10 min. and *Difference* of *Longitude* 52 deg. 55 min. and the greatest *Obliquity* 54 deg. 40 min. Work first with the less *Latitude*, to find the *Difference* of *Longitude* from the *Meridian* of *Obliquity* of both Places.

Thus,

As *Radius* to the *Co-Tangent* of *Obliquity* 54 deg. 40 min. —— 9. 85059
So is the *Co-Tangent* of the less *Latitude* 13 deg. 10 min. —— 9. 36909
To the *Co-Sine* of *Diff.* of *Long.* of *Barbadoes* 80 d. 27 m. —— 9. 21968

Because the *Difference* of *Longitude* of *Barbadoes* from the *Obliquity* is more than the *Difference* of *Longitude* betwixt the two Places, therefore subtract the *Difference* of *Longitude* between the two Places 52. d. 55 m. from 80 deg. 27 min. and there remains the *Difference* of *Longitude* of *Lundy* from the *Meridian* of *Obliquity* 27 deg. 32 min. But if the *Difference* of *Longitude* from the *Obliquity* had been less than the *Difference* of *Longitude* betwixt the two Places, then subtract the *Longitude* of the second Place from the *Obliquity* from the *Difference* of *Longitude* betwixt the two Places, and the Remainder had been the *Difference* of *Longitude* from the *Meridian* of *Obliquity*, to the first Place.

To find by what Latitude *the* Arch *ſhall paſs at any Degree of* Longitude *from the* Meridian *of the greateſt Obliquity.*

Suppoſe the *Longitude* from the *Meridian* of the greateſt *Obliquity* be 30 *deg.* the *Proportion* is as follows.

As *Radius* to *Tangent* of *Obliquity* 54 deg. 40 min. ——— 1014941
So is the *Co-ſine* of *Diff.* of *Longitude* from Obliq. 30 d. 00 —— 993753
To the *Tangent* of the *Latitude* 50 deg. 42 min. ——— 1008694

After the ſame manner I made this *Table*, of an *Arch* of a *Great Circle*, extended from *Latitude* 51 deg. 22 min. to *Latitude* 13 deg. 10 min. *Difference* of *Long.* 52 deg. 55 min. for every 5 deg. 55 min. That is, for every 5 deg. *Difference* of *Long.* Theſe are the *Latitudes* the *Great Circle* will paſs through.

Diff. of Longit. from Obliq. Lundy.		*Latitude.*	
Deg.	*Min.*	*Deg.*	*Min.*
27	32	51	22
30	00	50	42
35	00	49	07
40	00	47	13
45	00	44	56
50	00	42	12
55	00	38	58
60	00	35	12
65	00	30	47
70	00	25	46
75	00	20	03
80	27	13	10

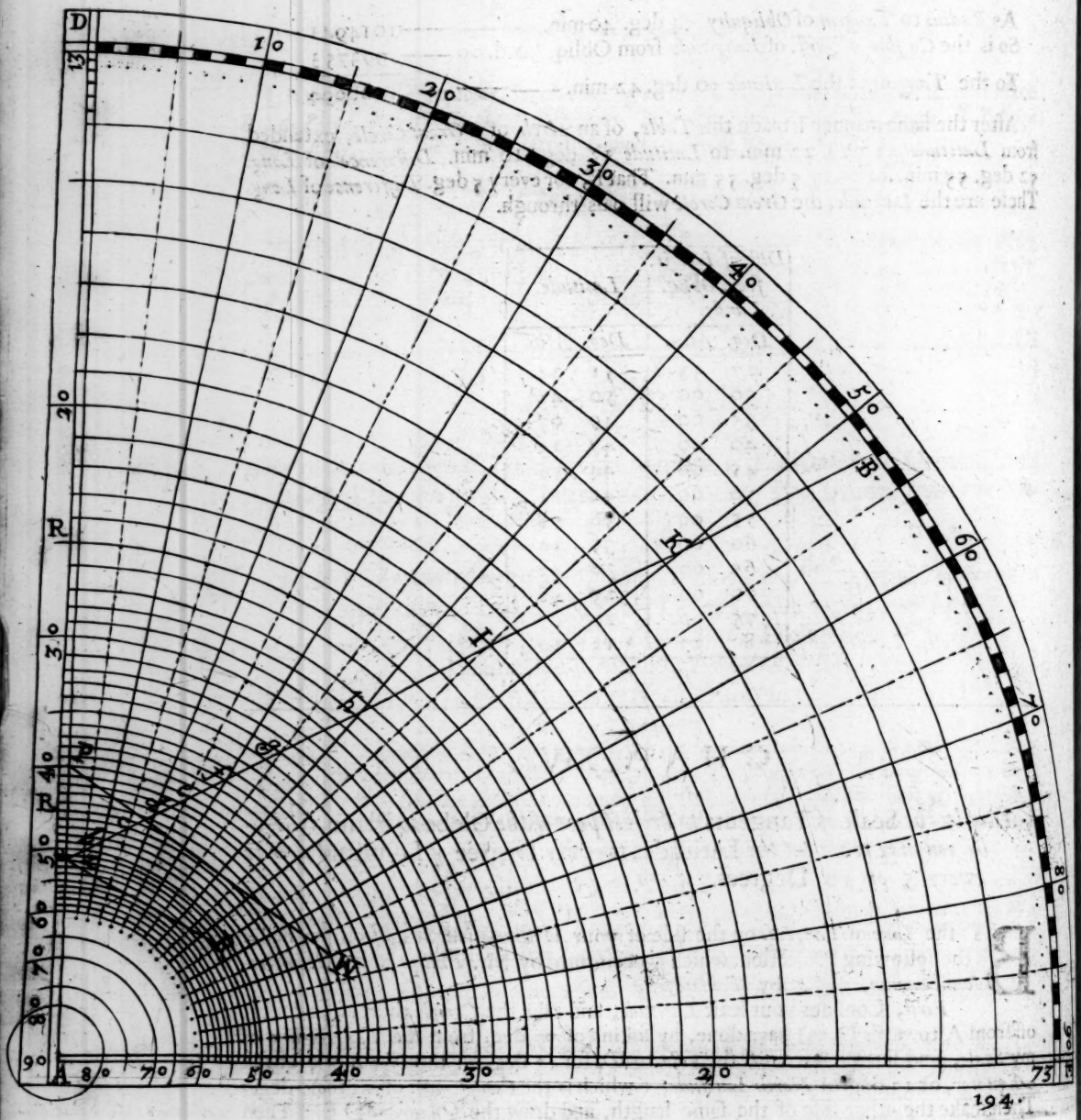
CHAP. XIV.

How by the Scale *of* Tangents *to Project part of the* Globe *in* Plano, *whereby you may trace out the* Latitudes *to every* Degree *of* Longitude, *or to every* 5 *or* 10 Degrees.

BY the *Line* of *Tangents* on the ſide of your *Mathematical Scale*, you may make the following Projection, which is performed by Mr. *Philips* in his *Geometrical Seaman*, *pag.* 5 by *Tables*.

Firſt, Conſider your leaſt *Latitude*, and take the *Compl.* thereof, and ſet it off from A towards D, as I have done, by taking of 77 deg. from the *Tangent-line* of my *Scale*, and ſetting it from A the *Pole* to *D*, for 13 deg. on the *North* ſide of the *Æquator*, or 13 deg. of *North Latitude*, (which is the *Complement* of 13 to 90 deg.) Then make the other ſide of the ſame length, and draw the *Quadrant* D E: Then with your *Compaſſes* take off the *Line* of *Tangents* the ſeveral *Degrees*, and draw the *Arches* or *Parallels* of *Latitude*, as you ſee I have done in the *Figure*. *Thirdly*, divide the *Limb* of the *Arch* D E into 90 deg. and through every 5 or 10 deg. draw *Lines* of *Longitude*, or *Meridian-lines*. The *Arches* of *Latitudes* muſt be numbred as in the *Figure*; but the *Lines* of *Longitude* you may number from either ſide, as occaſion requires.

You may, if you will, divide a Circle into four *Quadrants*, and draw the Lines of *Longitude* from the *Center*; and you may make this as large or as little as you will, by the *Tables* of *Natural Tangents* in the Second Book, as you have been ſhewed how to lengthen or ſhorten your *Radius*; You may number the *Circle* of *Longitude* with 360 *Degrees*.



The *Blank Quadrant*, being thus made, will ſerve for many *Examples*; eſpecially if you make it upon a *Slate*, that you may wipe out the *Arch*, that is lightly drawn by a *Slate Pen* betwixt any two Places.

You may ſet down therein the two Places you are to ſail between, according to their *Latitudes* and *Longitudes*; and then only by your *Ruler* draw a ſtreight *Line* from the one Place to the other, which will repreſent the *Great Circle* which paſſeth be-

between thoſe two Places, and will croſs thoſe *Degrees* of *Longitude* and *Latitude*, which you muſt ſail by.

Suppoſe a *Voyage* from *Lundy* in *Latitude* 51 deg. 22 min. to *Barbadoes*, in *Lat.* 13 deg. 10 min. *Difference* of *Longitude* 52 deg. 55 min. To find by what *Longitude* and *Latitudes* the *Arch* of a *Great Circle* drawn between thoſe two Places doth paſs.

Firſt, Let the *Line* A D repreſent the *Meridian* of the *Iſland* of *Lundy*, marked out by L for its *Latitude* 51 deg. 22 min. and the *Longitude* thereof 25 deg. 52 min. at D. Then from D in the *Limb* or *Arch* of the *Quadrant*, Count the *Diff.* of *Long.* 51 deg. 55 min. and this is the *Meridian* of the *Iſland* of *Barbadoes*, on which you muſt mark out the *Latitude* 13 deg. 10 min. at B; Lay a *Ruler* from the firſt *Latitude* L to the ſecond at B, and draw the ſtreight *Line* L B which repreſenteth the *Arch* of a *Great Circle* between the two Places; and if you guide your Eye along in this *Line*, you may readily and truly perceive by what *Longitudes* and *Latitudes* you ſhould ſail: For where this *Line* croſſeth the *Arches* of *Latitude*, and the *Lines* of *Longitude*, that ſhews the true *Longitude* and *Latitude* of the *Arch* according to your deſire.

Now the truth hereof will more evidently appear, if you compare the *Latitudes* and *Longitudes* which this Line interſecteth, with the *Table*, before Calculated for every 5 *deg.* of *Longitude*.

Difference of Longitude.	*Difference of Longitude from Oblquity.*	*Latitude.*	*Difference of Longitude from Lundy.*
Deg. Min.	*Deg. Min.*	*Deg. Min.*	*Deg. Min.*
52 55	27 32	51 22	00 00
2 28	30 00	50 41	02 28
5 00	35 00	49 07	07 28
5 00	40 00	47 13	12 28
5 00	45 00	44 59	17 28
5 00	50 00	42 12	22 28
5 00	55 00	38 58	27 28
5 00	60 00	35 12	32 28
5 00	65 00	30 48	37 28
5 00	70 00	25 46	42 28
5 00	75 00	20 30	47 28
5 27	80 27	13 10	52 55

You may ſee by the Figure, that the Line B L in the *Points* a, b, c, d, e, F, g, h, i, k, B doth croſs the *Parallel* of *Latitude*, in the third Column of this *Table*, at the number of *Degrees* from the *Meridian* of *Lundy*, as in the 4th *Column* of the *Table*.

As for Example.

I would know what *Degree* of *Latitude* 47 deg. 28 min. of *Longitude* from the firſt *Meridian* doth croſs; and I ſee by the *Figure* it is as the *Table* ſheweth at 20 deg. 30 min. of *Latitude*.

And ſo in like manner you may lay down upon the former *Quadrant* any two Places howſoever ſcituated, by their *Latitude* and *Difference* of *Longitude*.

CHAP. XV.

Containing several Propositions *of* Great Circle Sailing.

PROP. I.

By the Latitude, *and* Difference *of* Longitude *from the* Obliquity, *to find the* Great Circle Distance *from the greatest* Obliquity.

As *Radius* 90, to *Co-sine* of the *Latitude* 51 deg. 22 min. —— 979541
So is the *Sine* of the *Difference* of *Longitude* 27 deg. 32 min. —— 966489

To the *Sine* of the *Distance* 16 deg. 47 min. —— 946030

So that 16 *deg.* 47 *min.* is the *Great Circle Distance* from the *Point* of the greatest *Obliquity* of that *Circle*.

PROP. II.

By the Obliquity *of the* Great Circle, *to find the* Latitude *at any* Distance, *from the Point of the greatest* Obliquity.

As *Radius*, to *Sine* of greatest *Obliquity* 54 deg. 40 min. —— 991158
So is *Co-sine* of the *Distance* from *Obliquity* 16 deg. 47 min. —— 998109

To the *Sine* of the *Latitude* 51 deg. 21 min. —— 989267

Again,

As *Radius*, to *Sine* of greatest *Obliquity* 54 deg. 40 min. —— 991158
So is *Co-Sine* of *Distance* from *Obliquity* 73 deg. 47 min. —— 944602

To the *Sine* of the *Latitude* of *Barbadoes* 13 deg. 10 min —— 935760

PROP. III.

By the Great Circle's Distance *from the Point of* Obliquity, *and the* Latitude *given*; *To find the* Difference *of* Longitude *betwixt that place and the* Meridian *of greatest* Obliquity.

As the Co-*sine* of the *Latitude* 51 deg. 22 min. —— 979541

To *Radius*, So is the *Sine* of the *Dist.* from the *Obliquity* 16 d. 47 m. — 946052
To the *Sine* of the *Diff.* of *Longit.* 27 d. 33. m. —— 966511

PROP. IV.

By the Great Circle Distance *from the* Obliquity, *and the* Latitude *given*; *To find the* Angle *of* Position.

As *Radius* 90 d. to *Tang.* of *Great Circle Dist.* 16 d. 47 min. —— 947943
So is *Tangent* of the *Latitude* 51 deg. 22 min. —— 990267

To *Co-sine* of the *Angle* of *Position* 67 deg. 50 min. —— 957676

CHAP. XVI.

How to make the true Sea-Chart, *and the Uſe thereof in* Mercator's *and* Great-Circle *Sailing, being a general Chart.*

FOR the manner of the *Diviſion*, Let the *Æquator* be drawn and divided, and croſſed with *Parallel Meridians*, as before directed; only one *Degree* of *Longitude* in the *Particular-Chart* before-going, is 10 deg. of the *Æquator* of this *General Chart*. You have been directed how to make the *Meridian-line* off the Scale for a *Particular Chart*; and the ſame *Rule* makes this. Look in the *Table* of *Meridional parts*, and you will find the *Differenee* between the *Æquator* and 40 deg. of *Latitude* in the *Meridian-line* to be 874, 2 which is 874 *Leagues* and $\frac{2}{10}$; that divided by 20 is 43 deg. 42 min. of the *Æquator*, therefore out of a Scale of *Equal parts*, each degree of the *Æquator*, being divided into 20 parts, take 874 parts, and that *Diſtance* will reach from the *Æquator* to 40 deg. of *Latitude*.

And for 50 deg. take 1158 ſuch *Equal parts* (which is 57 deg. 54 min.) which will reach from the *Æquator*, to 50 deg. of *Latitude* in the *Meridian-line*: And ſo do for any other *Degree* or *Minute* of *Latitude*, untill you have made the *Chart*, as I have done in the *Figure*.

The Protracting Quadrant.

The *Protracting Quadrant* (you may ſee the *Figure*) ſhews you at ſight, without more words, how to make it by dividing it into eight *Points*, and each *Point* into four *Quarters*, and the *Arch* within into 90 deg. and a *Label* or *Index* to be rivetted to the *Center*, and a *Hole* drill'd through the *Rivet* to put a *Pin* through the *Center* of the *Quadrant*, to lay it upon any place aſſigned, and let it ſquare by the *Meridians* and *Parallels* of *Latitude*; ſo laying the *Center* to the firſt place of the *Index* over the ſecond Place, the *Limb* of the *Quadrant* will ſhew you the *Point* of the *Compaſs*, or what *Angle* it makes with the *Meridian*, *viz.* the bearing of the firſt place from the ſecond.

Now to trace out the *Arch* of a *Great Circle*, betwixt the places in a *Mercator's Chart*, in *Chap.* 13. you have the way how to calculate for any *Obliquity*, and to any degrees of *Longitude*; what *Degrees* and *Minutes* of *Latitude* the *Great Circle* ſhall paſs through; by the ſame *Rules* I have calculated, for every 10 *Degrees* of *Longitude*, reckoning from the greateſt *Obliquity*, to the *Interſection* of the *Great Circle* with the *Æquator*, viz.

Greateſt Obliquity G 54 *deg.* 40 *min.*

For *Deg. Long.*	10	20	30	40	50	
the *Deg. Lat.*	54 d. 15 m.	52 : 58	50 : 41	47 : 13	42 : 12	
For *Deg. Long.*	63	70	80 : 27		For *Deg. Longit.*	
Deg. Lat.	35 : 12	25 : 46	13 : 10		are 00 *Deg. Lat.*	

In this *Mercator's Plat*, G ſtandeth at 54 *deg.* 40 *min.* of North *Latitude*, and Æ juſt 90 *deg.* of *Longitude* Weſtward, and Æ N 90 *deg.* Eaſtward from G, being the two oppoſite *Points* in the *Æquator*, 180 deg. from each *Point* of *Interſection* Æ. Æ.

In every *Meridian* betwixt G and Æ, on both ſides (the *Meridians* being drawn at every 10 *deg.* of *Longitude* in the *Chart*) make a mark at the *Latitude* found in the Table, taking it from the *Meridian-line* of the *Chart*; And having ſo marked every *Meridian*, then by theſe marks draw *Arches* from one to another: or it will ſuffice to draw *Right Lines* from Mark to Mark, as from G (the greateſt *Obliquity* of the *Great Circle*) to the next *Meridian* on each ſide, and ſo to the next, until you come down to the *Æquator* at Æ on both ſides; ſo have you pourtray'd on this *Mercator Plat* a *Great Circle* from *Lundy* to *Barbadoes*, one being in North *Latitude* 51 *deg.* 22. *min.*

at

at L, the other at B in North *Latitude* 13 *deg.* 10 *min.* with *Difference* of *Longitude* 52 *deg.* 55 *min.*

He that will take the pains, will find great delight in this *Great-Circle-Sailing*. Yet I conclude, That although it is the neareſt way, it is not always the convenienteſt way for *Sea-men*, for ſeveral Reaſons known to them that can keep an *Account* of the *Ships way*, both by *Mercator*'s and *Great-Circle-Sailing*, which I could lay down here; but in regard it is needleſs, I leave every one to his diſcretion, and ſhall ſhew you the way how I did keep my *Account* at *Sea*, by *Mercator*'s *Chart*.

CHAP. XVII.

How to keep a Sea-Journal.

I Would not have any ingenious Artiſt, that hath a long time kept Account of a *Ship's way*, to think I preſcribe him *Rules*, but we only give directions for thoſe that are but young Learners, that ſo they may have a perfect Method of keeping Account of a *Ships way* at Sea.

To do this, I conceive it will be fit to have a Book in *Folio*, and to keep the left ſide of your Book void, that you may write all the *Paſſages* of the *Voyage*; that is to ſay, when you ſet Sail, with what Wind, and what Ships are in Company; what Storms, and how the Wind was: And likewiſe put down the time that you come by any misfortune, of cracking or breaking a Maſt or Yard, or if any Men ſhould die; and alſo what Damage you receive by any Storm, and the like Occurrences, as you ſhall think requiſite: and what Currents and Variation you meet with. But before all this, put down the Title of the *Voyage*, over the left-hand *Page*, in theſe or ſuch like Words, *viz.*

A JOURNAL *of our Intended* VOYAGE *by God's Aſſiſtance from* Kingrode-Port Briſtol, *in* Latitude 51 *deg.* 30 *min. to the* Iſland *of* Madara, *in* Latitude 32 *deg.* 10 *min. and from thence to* Barbadoes, *in* Latitude 13 *deg.* 10 *min.*

The right ſide of your Book throughout may be divided into 13 Columns, by Lines, as you may ſee in the following *Example*.

In the firſt muſt be expreſſed the Day of the *Month*. In the Second, the Letters of *Week-Days* that *Year*. In the third Column the *Months*; make it large enough to put down the *Latitudes* you make by Obſervation of the Sun or Stars, and Currents, how they ſet. In the fourth, the Courſe ſteered by the Compaſs. In the fifth, the Variation of the Compaſs, if there be any. Set down the Angle that the Rhomb maketh with the Meridian in the ſixth Column: And in the ſeventh, the Diſtance ſailed in Leagues or Miles. In the eighth, ninth, tenth, and eleventh Columns, ſet down the Northing, Southing, Eaſting and Weſting. In the twelfth, The Latitude by *Dead Reckoning*. And in the thirteenth Column, the difference of Longitude from the firſt *Meridian*, according to *Mercator*'s Chart.

Let this be your example.

We will frame a *Reckoning* between the three places before-mentioned, from *Lundy* to *Madera*, from thence to *Barbadoes*, whose distance in their *Rhombs* and difference of *Latitude*, and *Meridian distance*, I have put over in the head of the Columns in the left hand Page.

You see by the left-hand Page that we set sail the 25 day; but we entred it not in the right-hand Page until the 26th day at Noon: for it is to be understood, That since her setting sail *March* 25, to Noon of the 26th day, the Ship steers away and makes her Way good on the *S. b. W.* $\frac{1}{2}$ *W.* Point of the Compass; but the *Variation* being 5 deg. $\frac{1}{2}$ or half a point to the *Eastward*, as you see in the fifth Column, therefore the Point she hath made good upon is only *S. W.* 22 deg. 30 min. as is expressed in the sixth Column: Upon this Rhomb she sails 48 *Leagues*, as in the seventh *Column* appears: And answerable thereunto I find in the *Traverse-Table* before-going, the *Southing* to be 44 $\frac{31}{100}$ *Leagues*, or by the *Traverse-Scale* 44 $\frac{3}{10}$ *Leagues*; and the *Westing* 18 $\frac{11}{100}$ *Leagues*, by the *Travers-Scale* 18 $\frac{4}{10}$ *Leagues*, as here in the ninth and eleventh *Column* appears.

Not that I do affirm the Variation to be Easterly, for I know it to be 1 *d.* 30 *m. West; but being near the truth or not it serves to exemplify the Rule, that being the end for which this Example is made.*

The *Figures* to the left-hand signify *Leagues* in this *Journal*, and the two *Figures* to the right-hand signify the 100 part of a *League*. The *Southing* being 44 $\frac{31}{100}$ *Leagues*, which is 2 deg. 13 min. neerest; if that be subtracted from the *Latitude* from whence you came, *Lundy* 51 deg. 20 min. it makes the *Latitude* the Ship is in at Noon, to be 49 deg. 07 min. as appears in the 12th Column.

In the same manner, in the next line, being the 27th of *March*, sheweth, that from the 26th day at Noon, to the 27th day at Noon, she made her way good upon the *S. b. W.* $\frac{1}{2}$ Point of the Compass; but the *Variation* being 5 deg. $\frac{1}{2}$ *Easterly*, therefore the *Angle* of the *Rhomb* which the true *Meridian* was *S. W.* 22 deg. 30 min. and sailing 49 *Leagues*, the *Southing* is 45 $\frac{21}{100}$ *Leagues*, and the *Westing* 18 $\frac{11}{100}$ *Leagues*: So the *Latitude* is now 46 deg. 51 min.

To find the *Longitude* in the last Column, convert the *Easting* and *Westing*, that is, the *Leagues* in the East and West Column, into Degrees and Minutes of *Longitude*, by this Rule, which is near the Truth, provided these *Rhombs* differ not much one from another, by which Rule I found the *Longitude* for every *Sum* in the *Journal*.

Say then,

As the Difference *of* Latitude,
To the Departure *from the* Meridian:
So is the Difference *of* Latitude *in* Meridional Parts *or* Leagues.
To the Difference *of* Longitude *in* Leagues.

The Difference of *Latitude* in the South Column summ'd up (as you must do as often as you have any notable Difference betwixt your observed *Latitude* and *Dead Latitude*) is 136 $\frac{74}{100}$ *Leagues*; omit the last *Figure* to the right-hand $\frac{4}{100}$, and then it will be 136 $\frac{7}{10}$.

The *Departure* from the *Meridian* in the West Column is 56. 64; omit the last Figure, it is 566: So you put them down.

The Meridional parts *for the* Latitude 51 deg. 22 min. *is*	12002
The Meridional parts *for the* Latitude 44 deg. 30 min. *is*	9959
The Difference *of* Latitude *in* Meridional parts *is*	2043

Say

Say then,

As the Sum *of the* South Column, *or* Difference *of* Latitude 1367 — 313576

Is to the Sum *of the* West, *or* Departure *from the* Meridian 566 — 275281
So is the Difference *of* Latitude *in* Meridional parts 2043 ——— 331026

606307

To the Difference *of* Longitude in Leagues 84 $\frac{6}{10}$ ——— 292731

Which reduced into *Degrees* is 4 *deg.* 14 *min.* for the 28th. of *March.*

But let us proceed with our *Journal.* I obſerved the *Meridian Altitude* of the *Sun* the 31 day at Noon. I find my Latitude by Obſervation 38 *deg.* 30 *min.* which, by *Dead Reckoning* it, is 38 *deg.* 38 *min.* ſo the Difference is 8 min. Southerly; but being aſſured of a good *Obſervation,* I correct the *Dead Reckoning* thereby by this *Rule* of *Proportion,* ſaying,

As the Sum *of the* North Column 1201 ——— 307954

To the Sum *of the* Eaſt Column 520 ——— 271600
So is the aforeſaid Increaſing Southerly 27 ——— 143136

414736

To the Increaſing Weſterly $\frac{1}{10}\frac{7}{0}$ *Leagues* ——— 106782

Which is 1 *League* $\frac{1}{10}$, and ſomething more, not to be taken notice of.

This *Rule* of *Proportion* Mr. *Norwood* hath laid down in *Page* 111 of his *Seamans Practice,* in the Deſcription of his *Journal* from *Barmoodoes* or *Summer Iſlands* to the *Lizard*; which is thus.

Now this *Difference* being found, I put down in the *South Column* the *Difference* 2 $\frac{7}{100}$ *Leagues,* and the *Weſt Column* 1 $\frac{4}{100}$ *Leagues,* and under *Diſtance* 2 $\frac{9}{10}$ *Leagues*: Now the ſame corrected is by Obſervation 130 $\frac{9}{10}$ *Leagues,* 120 $\frac{1}{10}\frac{0}{0}$ *Leagues Southing* and *Weſting* 52 *Leagues* 8 *min.* ſubtracted from the *Dead Latitude,* make 38 *deg.* 30 *min.* the true corrected *Latitude* according to obſervation.

In like manner, upon the third of *April* I ſhould be in *Latitude* 32 deg. 19 min. but by very good obſervation, I find the ſhip in the *Latitude* 32 deg. 30 min. that is, not ſo much *Southerly* by 11 minutes: therefore to correct it by Obſervation, I put under *Diſtance* 3 $\frac{2}{10}$ *Leagues,* and in the *North Column* 3 $\frac{6}{100}$ *Leagues,* and in the *Eaſt* 1 $\frac{2}{100}$ *Leagues,* and under *Dead Latitude* 11 *minutes*: I ſubtract the corrected *Difference* of *Diſtance* out of the *Sum* over it, and likewiſe the corrected *Difference* in the *North Column* out of the *Sum* in the *South,* and likewiſe the *Eaſt* out of the *Weſt Column,* and add the 11 *min.* to the *Dead Latitude,* and then you have the *Sum* corrected: but if there be any *Current,* you may ſet it down, and allow for it, and note it down, as is that *Example* following the firſt of *April* to the third, and by your *Traverſe-Scale* preſently find how much the *Current* hath ſet you to the *Eaſt-ward.*

But if your *Courſe* be neer the *Eaſt* and *Weſt,* it is ſufficient to correct it in *Latitude* only, as in the *Example of the* 12th and 13th. of *May*; for in that Caſe the *Longitude* cannot be corrected but from ſome further ground. Now to ſet down this *Reckoning* upon the *Plain Chart,* or common *Sea-Chart,* every day, it is needleſs and unneceſſary: The better way is to ſet down every one of the *Sums* as they are corrected by Obſervation, in the ſame manner as you are directed

In ſailing Eaſt and Weſt, you have a Rule in Problem 7. *of Sailing by* Mercator *or* Mr. Writes *Chart.*

directed in the latter end of the third *Chapter* of this *Book*; and ſo by the total Sums of the *Difference* of *Latitude* and *Departure* from the firſt *Meridian*, you may ſet it down on your *Chart* as often as you pleaſe.

But if you are deſirous to ſet down your *Reckoning* in a *Mercator* or Mr. *Wright's Chart*, you have in the 12th and 13th. or laſt two *Columns* of your *Journal* the ſubſtance and principal ſcope of your *Reckoning*: ſet down as often as you ſum up or correct your *Reckoning*: namely, your *Latitude* and *Longitude*; which whenſoever you have a deſire to ſet down in the foreſaid *Chart*, or any other graduated *Chart*, with *Degrees* of *Longitude* and *Latitude*, you may readily do it.

As for Example.

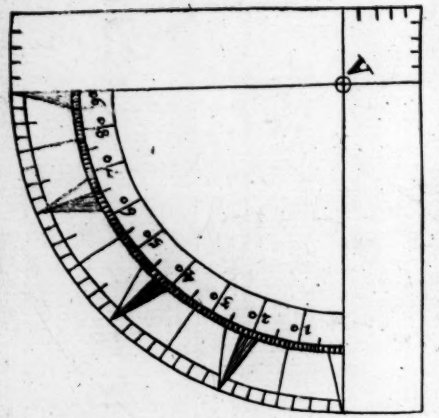
Suppoſe I would ſet down the place on the *Chart* where the Ship is, from the 25th of *March* to the 13th of *May*, I find the *Latitude* againſt the the 25th of *March* 51 deg. 20 min. and the *Latitude* of the *Barbadoes* 13 deg. 10 min. and the *Difference* of *Longitude* 52 deg. 35 min. Therefore in the *Latitude* of 13 deg. 10 min. I draw or point out an occult *Parallel*, and reckon 52 deg. 35 min. from the Iſland *Lundy* towards the *Weſt*: I draw by that *Longitude* an occult *Meridian*; the *Interſection* of this *Meridian* with the foreſaid *Parallel* is the *Point* repreſenting *Barbadoes*, or the Place of the Ship: and the like is to be underſtood of any of the other.

And ſo I put down in the *General Chart* of *Mercator* the 8 *Points* of the Ships Place, 1 a, 2 b, 3 c, 4 d, 5 e, 6 f, 7 g, 8 h, as there you may ſee.

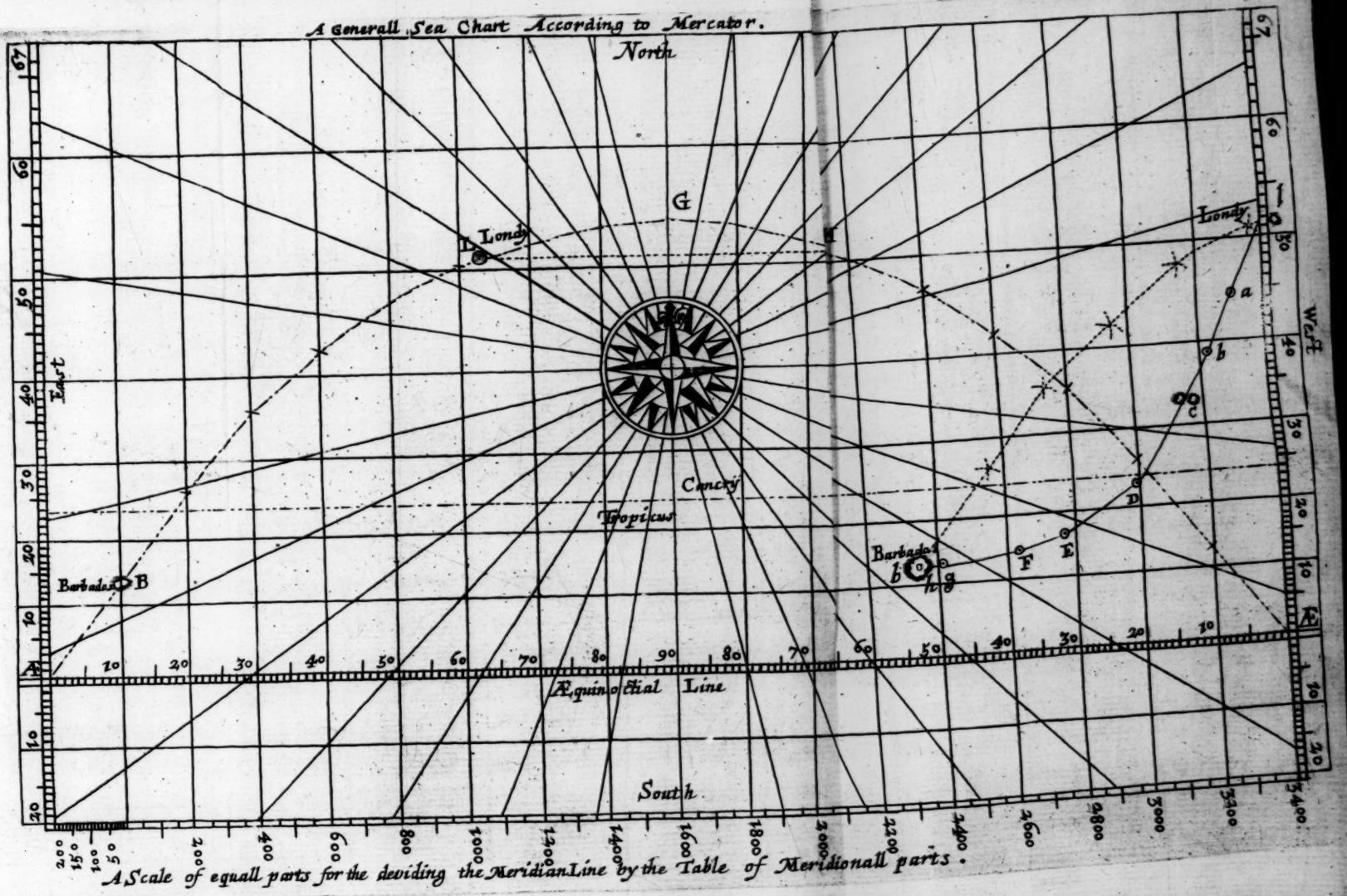
1666. *A Journal of our Intended Voyage, by Gods Assistance, in the Good Ship the* Eliz. *of* B. S. S. *Commander, from* Kingrode, *in Latitude* 51 d. 30 m. *to* Madara *in Latitude* 32 d. 30 m. *and from thence to* Barbadoes, *in Latitude* 13 d. 10 m.

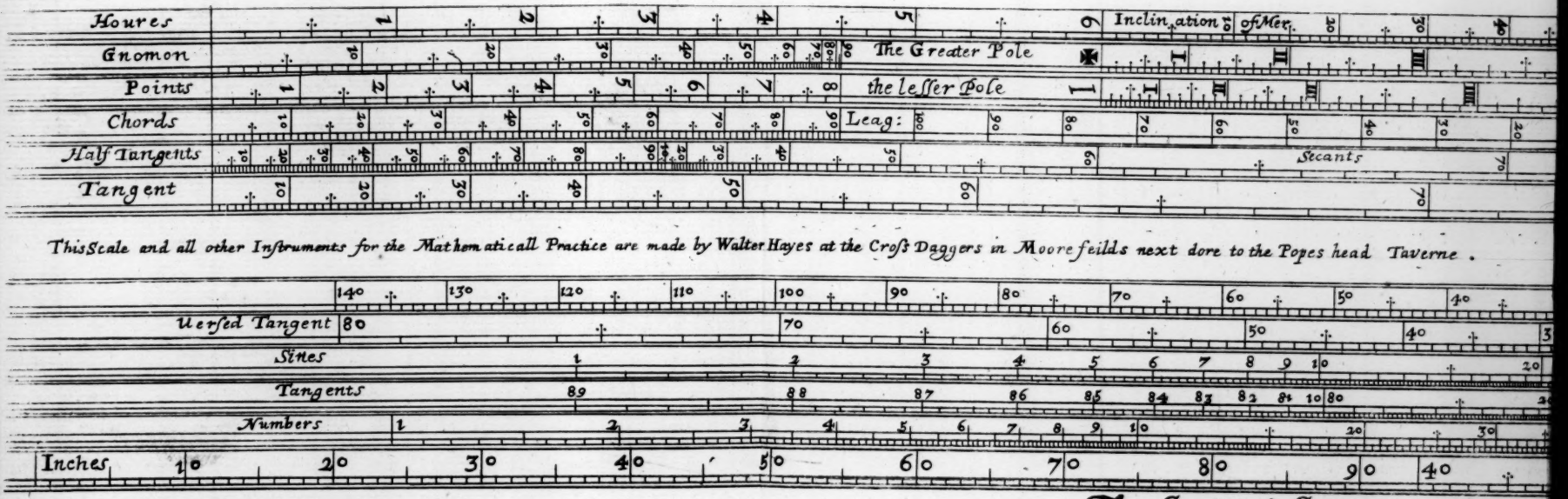
Month	Days.	week Days.	
March	25	a	Set sail out of *Kingroad*, in Company with the *John* bound to *Cales*, and *Anne* bound to *Virginia*; the Wind at *E. N. E.* thick rainy Weather.

Fasten this in with a Rivet to the Center of the Quadrant A. that it may turne upon it with a hole through the Rivet.



A Generall Sea Chart According to Mercator.

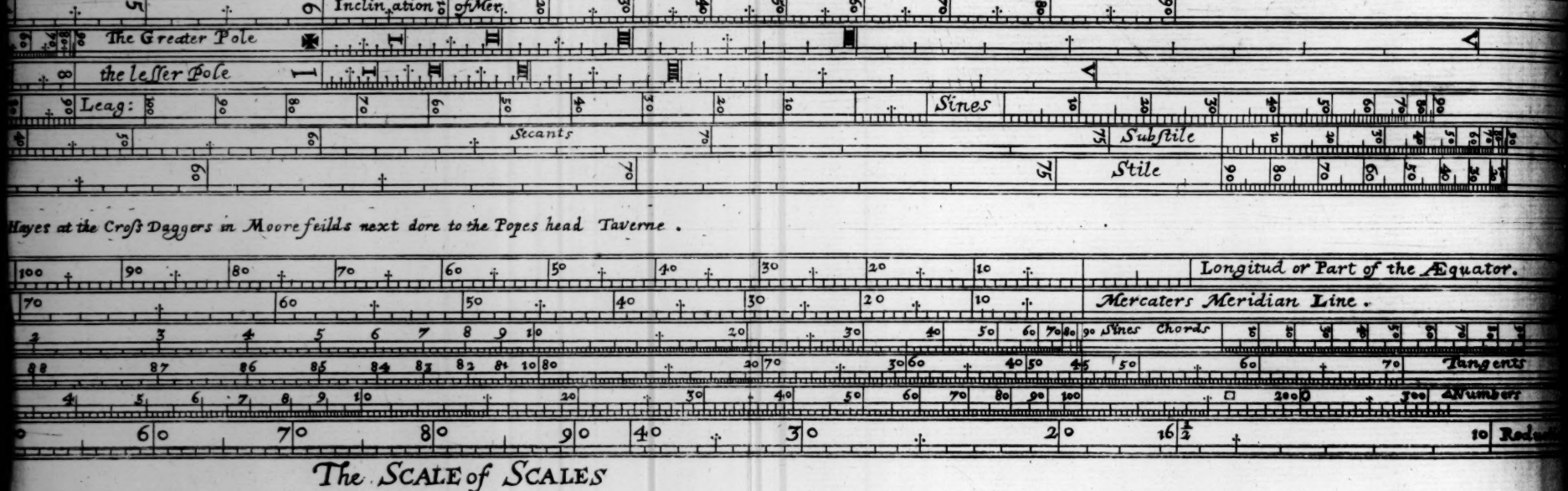




This Scale and all other Instruments for the Mathematicall Practice are made by Walter Hayes at the Cross Daggers in Moorefeilds next dore to the Popes head Taverne.

The SCALE of SCALES

These Naturall and Artificiall Scales are described at large with their Fundamentall Diagrams in the Second Booke of Mathematicall conclusions, with many other Instruments, the makeing and necessary use whereof is Dem



Hayes at the Crost Daggers in Moore feilds next dore to the Popes head Taverne .

The SCALE of SCALES

with their Fundamentall Diagrams in the Second Booke of this Treatise, and their Use exemplified in the Resolution of al
truments, the makeing and necessary use whereof is Demonstrated .

The Journal of our Intended Voyage, by God's Assistance, in the *E.* of *B. S. S.* Commander, from *Lundy*, in Latitude 51 *d.* 20 *m.* to the Island of *Madara*, in Latitude 32 *d.* 30 *m.* Course S. S. W. 1 *d.* and half West. Distance 411 Leagues, Meridian Distance 167 Leagues, Difference of Longitude 11 *d.* 16 *m.* from *Madara* to *Barbadoes*, in Latitude 13 *d.* 10 *m.* Course S. W. 61 *d.* 14 *m.* Distance 798 Leagues, Meridian Distance 698 Leag. Difference of Longitnde 41 *d.* 40 *m.*

			Course	East Variation.	Deg. from the	Dist.	Di. La	Dif. La.	dep.	Dep.	51d.20	diff. Lo.
			S S W		Merid. SW 25 d	411	377	377	167	167	32d.30'	11d.16'
			S W b W half W		S W 61 d. 14 m.	798	387 le	387 lea.	698	698	13d.10	41d.40'
		Latitude by Observation.	Course by Compass.	Variation of Compass.	Degrees from the Meridian.	Diff. sailed.	North	South.	East.	West	Lat. by dead R.	Diff. of Longit.
		Deg. Min.	Points.	Degrees.	Degrees.	Leag.	Leag.	Leag.	Lea.	Leag.	D. M.	D. M.
26	a	Set sail March 25.	S by W half W	5 deg. 30 min. E	S W 22 d. 30 m.	48		44 35		18 37	49 07	
27	b		S by W half W	5 deg. 30 min. E	S W 22 d. 30 m.	49		45 27		18 75	46 51	
28	c	44 deg. 31 min.	S by W half W	5 deg. 30 min. E	S W 22 d. 30 m.	51		47 12		19 52	44 30	
28			Add up the Numbers, the sum is			148		136 74		56 64		04 14
29	d		S S W	2 deg. 45 min. E	S W 25 d. 15 m.	43		38 87		18 38	42 34	
30	e	40 deg. 27 min.	S S W	1 degree East	S W 22 d. 30 m.	46		42 50		17 60	40 26	
31	f	38 deg. 30 min.	S S W	0 degree East	S W 22 d. 30 m.	39		36 03		14 92	38 28	
			Add up the Numbers, the sum is			128		117 40		50 90		
			Correction by Observation			2 9		2 70		01 10	8	
			The sum corrected is			130 9		120 10		52 00	38 30	07 43
			Difference of Latitude, Depart. from first Merid.			278		256 84		108 64		
1	G	April, a Current	S W b S	11 d. 30 m. Cur.	S W 22 d. 30 m.	43		43 42		17 99	36 17	
2	a	sets E. by S.	S W b S	11 d. 30 m. Cur.	S W 22 d. 30 m.	45		41 57		17 22	34 12	
3	b	32 deg. 30 min.	S W b S	11 d. 30 m. Cur.	S W 22 d. 30 m.	42		38 80		16 07	32 19	
		Set to the East-	Add up the Numbers, the sum is			134		123 79		51 28		
		ward by the Cur-	Correction by Observation			3 93	66		1 50		11	
		rent in 3 days, 22	The sum corrected is			131		120 13		49 78	32 30	10 46
4	c	Leag. and almost	Madara Island bears West distant			8.58				8 58		
		half E b S. by esti.	Difference of Latit., Depar. from the first Merid.			418		376 97		167 00	32 30	11 16
24	b	Set sail April 23.	S W b S	5 d. 30 m. East by Current.	S W 28 d. 30 m.	36		31 75		16 97	30 55	
25	c	from Madara.	S W b S	2 d. 45 m. East	S W 30 d. 45 m.	46		39 46		23 65	28 57	
26	d	27 deg. 43 min.	S W b S		S W 33 d. 45 m.	30		24 94		16 67	27 42	
27	e	25 deg. 54 min.	S W		S W 45 deg.	51		36 06		36 06	25 55	
28	f	23 deg. 47 min.	S W		S W 45 deg.	60		42 43		42 43	23 48	
29	G	22 deg. 40 min.	S W		S W 45 deg.	28		19 80		19 80	22 47	
			Numbers added, the sum is			134		194 44		155 58		
			Correction by Observation			3		2 30		1 90	7	
			Sum corrected is			154		196 74		157 48	22 40	
29			Difference of Lat. Depart. from first Merid.			572		573 71		324 48		20 47
30	a		S W b W	00 degr.	S W 56 d. 15 m.	45		25 00		37 42	21 25	
1	b	May	S W b W	00 degr.	S W 56 d. 15 m.	47		26 11		39 08	20 07	
2	c	18 deg. 57 min.	S W b W	00 degr.	S W 56 d. 15 m.	43		23 89		35 75	18 56	
	d		S W b W	00 degr.	S W 56 d. 15 m.	44		24 44		36 58	17 43	
	e	16 deg. 50 min.	S W b W	00 degr.	S W 56 d. 15 m.	39		21 67		32 43	16 37	
			Add up the Numbers, the sum is			218		121 11		181 26		
			Correction by Observation			7 84	33		6 50		13	
			Sum corrected is			210 2		116 78		174 76	16 50	
4			Difference of Latit. Depart. from first Merid.			782 2		690 49		490 24		31 06
5	E	16 deg. 14 min.	W S W half W	5 degr. W	S W 67 d. 30 m.	31		11 86		26 64	16 15	
6	G	15 deg. 03 min.	W S W half W	5 d. 30 m. W	S W 67 d. 30 m.	46		17 60		42 50	15 22	
7	a		W S W half W	5 d. 30 m. W	S W 67 d. 30 m.	33		12 63		30 49	14 44	
8	b	14 deg. 03 min.	W S W half W	5 d. 30 m. W	S W 67 d. 30 m.	30		11 48		27 72	14 09	
			Add up the Numbers, the sum is			140		53 57		127 35		
			Correction by Observation			5 2		2 00		4 80	13	
			Sum corrected is			145 2		55 57		132 15	14 03	
8			Difference of Latit. Depart. from first Merid.			927 4		146 6		631 39		38 50
9	c	13 deg. 48 min.	W b S half W	5 deg. half	S W 84 d. 20 m.	55		5 39		54 73	13 47	
10	D		W b S half W	2 deg. 50 m.	S W 87 d. 11 m.	60		2 94		59 92	13 39	
11	e	13 deg. 10 min.	W b S half W	00 deg. 00 m.	S W 78 d. 30 m.	51		9 95		50 02	13 09	
		Ship's in Lat. Bar-	Add up the Numbers, the sum is			166		18 28		164 67		
11		badoes 69 lea. Ea	Difference of Latit. Depart. from first Merid.			1092		164 34		796 06		48 41
12	f	13 deg. 00 min.	West	5 d. 30 Cur. sets	S W 84 d. 22 m.	39		3 80		38 60	12 59	
13		The Current set S	W by N	S. 2 d. 45' Cur.	S W 81 d. 30 m.	26	81			25 71	13 10	
13	G	13 deg. 11 min.	Difference of Latit. Depart. from Lundy			1163		764 33		860 37	13 10	52 39
13		Barbadoes Island bears West distant of Leag.				5						

CHAP. XVIII.

A Deſcription of the following Table *of the* Latitude *and* Longitude *of Places, and the way how to find both.*

THE ancient *Geographers*, from *Ptolomy*'s time downward, reckoned the *Longitude* of Places from the *Meridian*, which paſſeth through the *Cape de Verde Iſlands*; and others have the beginning at the *Canary Iſlands*; and *Jodocus Hondius* beginneth at the *Iſle Pico* one of the *Azores*; and Mr. *Emery Mullineux* doth account the *Longitude* from the *Weſtermoſt* part of St. *Michaels*, another *Iſland* of the *Azores*: who albeit they differ greatly in reſpect of the beginning of their ſeveral *Longitudes*, they come all to a pretty near agreement for their *Difference* of *Longitude* from any particular Meridian or Place: and for the exact ſetling of *Latitudes*, we have many certain helps; but the *Longitude* of Meridians hath ſtill wearied the moſt able Maſters of *Geography*.

By *Latitude* and *Longitude*, the *Geographers* ſtrive to repreſent the Parts of the Earth, that they may keep Symmetry and Harmony with the whole.

A TABLE OF THE *LONGITUDE* and *LATITUDE* Of the moſt Notable Places, OF THE WORLD.

Compoſed after a new manner, by beginning the ſaid *Longitude* at the *Meridian* of the moſt *Southern* Port of *England*, the *Lizard*.

By Capt. SAMUEL STURMY.

The Sea-Coaſt of New-found-Land, *and* New-England.

The Places Names.	*North Latitude* D.	M.	*Weſt Longit.* D.	M.
Cape Honblanto	52	11	50	14
Belile	51	02	48	44
Cape Bonaviſta	49	19	47	42
Trinity *Bay*	48	54	49	04
Bacalao *Iſland*	48	40	46	55
Conſumption *Bay*	48	21	47	49
Cape St. Francis	48	01	47	27
Cape Deſpaire	47	36	46	03
Cape de Raca	46	27	46	30
Bay Bulls	47	28	47	11
St. John's *Harbour*	47	47	47	21
Plaſantia *Bay*	47	32	47	41
Cape St. Larinſo	47	10	48	59
Iſland St. Paly	47	36	50	18
Cape Raya	48	05	52	49
Cape Deganica	54	01	53	21
New-Eng. *Cape* S. Charles	52	48	52	23
Cape Brittan	46	01	52	57
Cape Salila	43	46	55	22
Cape Codde	42	21	61	32
Boſton	42	30	64	36
Plymouth	42	07	62	35
Nantucket	41	08	60	17
Mattins Tinyard	41	17	61	12

The Sea-Coaſts on the main Continent in America, *or* Weſt-India.

The Places Names.	*Latit.* D.	M.	*Longit.* D.	M.
Elizabeth *Iſland*	41	02	62	04

Bloik

The Places Names.	*North Latit.* D.	M.	*West Longit.* D.	M.
Bloik Iſland	40	55	62	36
Long Iſland	40	45	63	16
Cape May	39	55	64	45
Virginia. Cape Charles	37	47	65	26
Cape Henry	37	01	65	38
Cape Hatcraſs	35	49	65	46
Cape Fara	34	06	69	56
Cape de Catocha	21	23	80	37
Cape de Camaron	16	05	76	19
Cape de Gratias	15	31	70	56
Cattergaine	10	24	65	06
Bay Tonto	12	10	62	36
Cape St. Roman	11	55	60	36
Cape Dacodara	11	08	56	38
Cape Trag, or 3 *Points*	11	17	55	41
Cape Brama	09	21	54	16
Cape Dasbaſſas	08	20	53	11
Suramo	06	09	50	56
Suranam	05	58	49	52

The Weſt-India Iſlands.

The Places Names.	*North Latit.* D.	M.	*Weſt. Longit.* D.	M.
Defonſſeaca Iſland	12	23	48	30
La Burmuda	32	25	56	00
Behama	27	57	73	06
Teavis	27	27	71	04
Sigvatro	26	18	68	45
Guatro	25	47	68	00
Guamina	25	15	67	53
Tiango	24	33	66	30
Guanahimo	23	50	66	39
Mayaghana	23	05	66	51
Cayeoſs	22	05	64	31
Amiana	21	40	64	38
Inagua	21	19	67	03
Yamatta.	22	32	67	49
Soamia	24	20	68	50
Javaqua	25	10	71	30
Yamia	24	22	70	10
St. John	18	30	60	42
Santa Cruce	17	42	59	18
Anguilla	18	48	57	00
St. Martin	18	35	56	47
St. Bartolama	18	15	56	33
Barbada	17	18	55	39
Antego	16	31	54	52
Daſſijada	16	00	54	36
Marigallatita	15	41	55	26
Dominica	15	00	55	05
Mattalina	14	20	54	44
St. Lucia.	13	30	54	43

The Places Names.	*North Latit.* D.	M.	*Weſt. Longit.* D.	M.
Barbadus	13	10	52	58
Tobago	11	12	53	06
Point Degallaia	10	45	53	31
Gianaca	11	10	54	32
St. Vincent	12	50	54	28
Guardadupa	16	00	55	31
Monſariat	16	20	55	41
Maves	17	00	56	27
St. Criſtova	17	30	56	45
Iſland Devas	15	57	57	28
Iſland Blanco	12	20	56	52
Margaita	11	28	56	37
Turtuga	11	30	57	40
Iſland Derickilla	12	19	58	01
Boca	12	19	58	53
Iſland Deavos	12	29	59	22
Bonoga	12	32	60	54
Quiſſa	12	25	60	39
Moagos	12	20	61	55
East end of Hiſpaniola	18	47	62	28
Middle of Hiſpaniola	18	30	64	58
Weſt end of Hiſpaniola	18	25	68	26
East end of Jamaica	18	00	71	58
Jamaica *Harbour*	18	15	72	57
Weſt end of Jamaica	18	38	74	37
The East end of Cuba	22	00	75	56
Caimanis	19	41	77	41
Grand Caiman	19	21	78	45
Santavilla	17	28	77	50
Moſquito	14	50	76	04
Guanabo	16	33	81	19
Guanabimo	16	10	83	04
Cozumal	19	25	84	56
Lafalleeranas	22	00	87	58
The Iſland Delas	23	30	91	58
Abraio	25	50	94	00
Labarmaia	22	55	93	16
Iſland Dearanas	22	36	93	14
Triango	21	23	93	05
Zarka	20	50	93	00
The Iſland of Prondanco	13	27	81	16
St. Andrea.	12	42	80	57

The Sea-Coaſts of Brazilia.

The Places Names.	*South Latit.* D.	M.	*Weſt Longit.* D.	M.
The River Amazons	00	00	41	30
The Iſland *of St.* Paul	00	55	14	36
The Iſland *of* Aſcenſion	07	48	20	00
Cape Blanco	02	25	22	29
Iſland Rocas	03	42	7	16
Iſland Farnando	03	40	15	16

Abratho

The Places Names.	*South Latit.* D.	M.	*Weſt Longit.* D.	M.
Abratho	05	00	17	56
Cape St. Raphali	06	10	19	36
Cape St. Auguſtin	08	25	18	28
River St. Mignal	09	30	19	01
The River Roal	11	21	20	41
River Gianda	14	49	22	06
Cape de Abeotho	17	52	21	42
St. Harbara.	18	11	21	06
Iſland Aſcenſion	17	19	17	01
Trinidada	19	50	14	24
St. Maria Dagaſta	19	38	12	14
Iſland de Martin	19	00	08	03
Iſland de Pidos	21	52	05	51
Cape St. Toma	21	47	23	38
Cape Frio	22	52	24	43
Cape St. Maria	35	00	37	11
River de Platta	35	50	45	52
Port St. Juliano	50	00	52	30
The Sreights of *Magellane*	53	30	56	30
Cape de Sancto Spirito	52	20	58	30
Cape Victoria, *Weſt end of the* Streights	52	30	65	40
Lima Cape	12	00	80	30
Cape Guya, Cape Blanco	06	10	85	30
Cape St. Frainſco	01	30	80	30
Cape St. Frances	*North.*		*Weſt*	
Point de bon matre	07	30	80	00
Nombre de Dios. *W. Sea*	10	00	77	30
Nova Albion, *or* New England, *in the South Sea, the back ſide of it*	46	00	162	30
Cape de Fortuna (Aniar. fra.	55	30	170	00
Inſulæ Salamonis	*So. Lat.*		*W. Long.*	
Nombre de Jeſus	05	50	169	30
Tapan Inſule.	36 *N.*	00	153 *E*	00
Cape de Buena Deſco	01 S.	00	155	00

The East India *Iſlands.*

The Places Names.	*South Latitude* D.	M.	*East Longit.* D.	M.
Hipon Iſland	06	45	125	20
Bantam, East-India	06	15	115	34
Jamba Iſlands	01	49	125	25
South *end of* Sumatra	05	52	125	48
Middle end of Sumatra	01	30	120	49

The Places Names.	*North Latitud.* D.	M.	*East Longit.* D.	M.
North *end of* Sumatra	05	28	116	35
Gomaſpala	05	40	116	29
Niobar	07	00	115	04
Iſland Deſombro	08	00	114	44
Iſland Ruſta	09	50	114	33
Quarinibar	11	10	114	44
Chitra Andomaio	12	00	114	41
Iſland Dandemajo	13	00	114	39
Iſland Decocoſs	14	30	115	12
Celloan	07	50	93	39
Doda Safia	09	40	93	02
Andaio	11	30	90	51
Garine	10	50	90	56
Moique	09	05	91	29
Cuballa	05	53	91	07
Iſland de Proſol	10	23	90	55
Iſland de Zocha	11	12	90	45
Chorebaman	12	32	87	55
Sucatra	12	18	74	01
Abdelcari	12	12	71	44
Apoluaria	09 S.	20	90	50
Adu	05	39	88	50
Degomo.	02	40	87	35
Piedros Blancho	06	10	76	55
Diego gratioſa	08	30	78	15
Set Hermanas	03	02	70	25
Domes Caicuhas	03	21	65	24
Iſland Quellallo	03	40	64	20
De Almiranta	03	57	63	28
Agnalaga	09	00	66	15
Aſdore Has	09	05	65	02
John de Nava	09	00	63	26
Coſmobodo	09	40	61	52
Donatall	08	20	59	57
Aignos	09	30	58	18
John de Comoro	09	00	57	20
Pemba	05	09	53	30
Zanziba	06	26	53	35
Manfia	07	50	53	08
John Demiz	10	48	54	24
Comoro	11	20	55	48
Monhalla	12	11	56	25
Foanna	12	09	57	03
Mayatta	12	40	57	55
St. Chriſtopher	14	30	56	03
John de Nova	17	20	55	29
Baſlas de India	22	10	55	22
North end of St. Laurence.	25	37	60	54
St. Apohima	20	50	65	54
Domſcaicahas	20	50	66	54
Moroſlaſs	20	20	68	44
Doſgarias	15	20	70	43
St. Branda	17	13	74	44

The Places Names.	*South Latitud.* D.	M.	*East Longit.* D.	M.
Englands Foreſt	20	50	74	14
Diego Roize	20	05	75	54
John de Lisbone	25	24	68	32
Romoras	28	19	81	21

The Sea-coaſt on the Main Continent in the East India.

The Places Names.	*North Latit.* D.	M.	*East Longit.* D.	M.
Malacca	01	41	116	14
Queda	06	47	117	44
River de Care	10	45	118	54
River Bongale	22	09	121	33
Aicopoir	20	19	112	39
Samnabron	18	30	108	52
Arme Gon	14	35	100	27
Naga Patam	11	21	99	59
Cape Comorin	07	50	97	39
Cochin	09	40	97	29
Callant	10	48	97	27
Mongalar	12	40	97	19
Dodall	17	01	98	55
Goa	14	40	97	01
Chaul	18	10	98	51
Calecut *in* East India	11	30	92	58
Macao *in the K. of* Pegu	19	30	112	49
Demon	11	54	99	01
Surrat	21	00	99	36
Dio	20	48	96	57
River Decinda	24	55	95	39
Gudar	24	50	89	28
Cape Muchoaridan	25	32	82	39
Cape Ruſſalgat	22	07	84	39
Cape de Ponto	18	19	79	09
Dofar	17	00	75	04
Cape de Matriaia	15	33	72	39
Adon	13	08	66	56
Cape Guardafuy	11	40	71	24
Cape de Baſſos	04	30	65	19
Magadox	02	30	59	24
Molinda	02	*S.* 42	52	11
Tanga	05	20	52	01
Cape Faſſto	08	02	52	24
Daghada	15	17	53	26
Cape Corintes	23	30	48	51
Cape St. Marin	25	40	46	59
River St. Luſſea	28	25	46	09
Bay Doliagoa	33	18	43	59

The Sea-coaſt from Cape Bone Eſprance *to* Guiney.

The Places Names.	*South Latitude* D.	M.	*East Longit.* D.	M.
Iſland Deſitian	36	57	11	44
Iſland Degiaiatica	37	56	14	04
Cape Agullas	36	20	33	54
Cape Bone Eſprance	35	50	32	54
Cape Sacos	29	40	30	14
Aſcention Iſland	07	48	05	24
St. Elana	16	03	10	08
St. Elana Nova	16	03	19	48
Baſſas	17	45	27	35
Cape Lado	10	00	29	23
Cape Padron	06	00	29	04
Cape Lopas	01	00	25	21
Anabona Iſland	01	22	22	56
Iſland St. Mathaos	01	40	07	45
Iſland St. Toma	00	*N.* 10	13	34
Iſland Chocos	00	40	23	50
River Gaboan	00	10	27	16
River de Angai	01	00	27	30
Iſland de Principas	01	50	25	14
Iſland Defarnanda	03	10	26	06
River Boilin	02	42	27	29
River Decainaronas	04	00	27	09

The Sea-coaſt from Samſons *River to the River of* Gambo, *Coaſt* Guiney *and* Barbary.

The Places Names.	*North Latitud.* D.	M.	*East Longit.* D.	M.
Old Callabar	04	50	25	15
New Callabar	04	40	23	37
Cape Formoſſus	04	03	22	52
River Binnin	06	50	22	12
River Dallagoa	07	40	19	49
River de Valta	06	05	16	52
Cape 3 Points	04	10	13	10
River St. Andraſs	05	23	08	06
Cape de Palmas	04	40	06	05
River de Caſto	05	20	03	48
Cape Mounta	05	23	01	46
Cape Roxo	11	38	6	*W.* 13
River of Gambo	12	47	2	17
Cape de Verd.	14	24	6	57

The Cape de Verd Iſlands.

The Places Names.	*North Latit.*		*Weſt. Longit.*	
	D.	*M.*	*D.*	*M.*
Abrolho	00	00	16	16
Vigia	03	01	10	10
St. Paul	01	32	14	56
Rochaſs	02	30	16	16
Varo	11	12	12	07
Vigia	12	26	19	48
Abrogo	16	36	10	19
Brava	14	49	15	14
Fogo	14	42	14	56
Lantiago	14	52	14	22
Maya	15	00	14	02
Bouaniſta	15	58	13	49
Sall	17	00	13	26
St. Nicholas	16	30	15	44
St. Lucia	16	50	16	08
St. Tincant	16	55	16	32
St. Antonio	17	07	16	56
Cape Blanco	20	30	9	26
Cape Boyadojo	26	55	2	52
Marquepana	27	22	2	11
Cape Denao	28	52	1	46
Cape Gillam	29	50	1	29
Cape de Gaato	30	30	1	25
Cape Cantin	32	27	1	06
Tangire *Eaſt Longitud.*	35	36	1	49

The Sea-Coaſts on the Main, *from* Tangire *to* Joppa *in the* Straits.

The Places Names.	*North Latit.*		*Eaſt. Longit.*	
	D.	*M.*	*D.*	*M.*
Wadallo *in the* Straits	34	57	3	13
Ballis	34	57	3	48
Oran	35	46	7	59
Tanis	36	30	9	18
Sally	36	40	9	48
Argier	36	40	10	54
Tadallis	36	48	11	25
Ragin	36	50	11	44
Gion	36	50	13	30
Gigaria	37	03	14	26
Colla	37	09	15	14
Stora	37	09	15	44
Bona	37	19	16	44
Bozarat	37	30	17	50
Tunis	36	50	17	24
Cape Beun	37	05	18	11
Suſſa	36	02	18	07
Britto	35	23	18	41
Cherunne	34	56	18	36
Cape Mizarrata	32	18	24	00
Cape de Solli	31	1	25	49
Cape Ruſſutta	32	58	29	26
Cape Roattini	32	18	32	04
Alexandria	30	40	41	28
Michallat	30	30	41	55
Cairo	30	35	41	44
Joppa	31	42	43	39

The Coaſt from Antiochia *to* Sagua *in the* Straits.

The Places Names.	North *Latit.*		*Eaſt Longit.*	
	D.	*M.*	*D.*	*M.*
From Antiochia *to* Sagua	34	54	46	26
Cape Pollopolla	35	35	44	01
Cape Seridioni	35	55	41	24
Cape Decoxman	36	16	36	44
Cape Babarnau	37	58	36	22
Land Miri	39	12	37	05
Incommodio	40	26	40	39
Conſtantinople	40	56	40	33
Gallippolo	40	20	37	59
Cape Degriffa	40	12	37	11
Cape Pimra	40	26	32	23
Cape St. George	39	28	32	10
Cape Collo	37	40	32	35
Cape Sille	37	15	31	52
Cape Matapan	36	28	30	53
Caſteltornis	37	45	30	32
Drugromaſtra	38	38	30	40
Cape Linga	40	18	29	38
Hiraſſa	40	57	30	38
Antavara	41	49	30	54
Cattaro	42	21	29	47
Raguſſa	42	29	28	57
Stanio	42	57	28	11
Trovor	43	30	27	37
Cape Caſta	43	27	26	48
Salconico	44	01	27	24
Zaro	44	05	26	39
Sagua	44	47	25	49

From Cape Fiſtria *to* Giblitore.

The Places Names.	*North Latitude* D.	M.	*East Longit.* D.	M.
Cape Fiſtria	44	40	24	10
Venetia	45	37	22	45
Gorro	44	57	21	35
Giavocha	44	19	21	26
Ancana	43	25	24	29
Angollo	41	31	27	02
Cape St. Maſſa	39	52	26	53
Gallipoli	40	08	27	04
Cape Callom	38	50	25	40
Cape Sparta-venta	37	46	24	16
Pollicaſtro	40	08	24	02
Sallarno	40	51	23	32
Napolis	41	08	22	51
Rome	41	50	21	09
Ciritacha	41	46	20	24
Leagueorne	43	28	19	03
Cape Malle	43	51	15	37
Cape Larci	42	58	14	38
Tallone	43	00	14	04
Marſilia	43	12	12	44
Cape Degofrito	41	41	11	18
Cape Pallomallo	40	10	8	39
Cape Martin	38	46	8	20
Allagant	38	20	7	14
Cape Paul	37	28	7	11
Cape Degat	36	47	5	24
Valis	36	49	3	33
Malagoe	36	45	3	07
Giblitore.	36	40	2	06

The Iſlands in the Straits, *called the* Archipelago.

The Places Names.	*North Latit.* D.	M.	*East Longit.* D.	M.
Sarfanto	36	57	33	39
Sarfo	37	17	33	22
Famania	37	28	33	18
Trava	37	49	34	41
Pipor	39	32	33	51
Laſſor	39	58	33	51
Lamo	39	44	33	38
Stripo	39	16	33	51

The Places Names.	*North Latitud.* D.	M.	*East Longit.* D.	M.
St. Penaga	38	52	33	03
Andrea	38	12	34	46
Ipſava	38	28	35	11
Mortalin	39	54	35	52
Staviſratta	39	28	35	14
Lamnoſs	39	41	35	49
Embroſs	40	09	36	09
Palamos	40	14	36	04
Toſſa	40	00	35	19
Iſlands *in the* Straits.				
Sapientia	36	47	30	16
Stouty	37	10	29	43
Zant	37	37	29	38
Cape Sidro	38	15	29	33
Paxa	38	49	29	30
Corfu	39	26	29	26
Faimo	39	44	29	19
Seſſino	40	22	29	14
Pianaſſa	41	52	26	08
Trinite	41	50	25	53
Pollagaſſa	42	17	26	37
Mallida	42	37	28	03
Corſella	42	35	27	38
Auguſta	42	36	27	13
Catſſalla	42	40	27	03
Catſſo	42	44	26	58
Liſſa	43	00	26	33
Buzo	43	02	26	18
St. Androa	43	07	25	58
Poma	43	14	25	48
Iſland Groſſo	44	00	25	36
Sauſſaga	44	20	25	02
Piper	35	52	22	15
Malta	36	00	11	54
Comino	36	15	21	24
East end of Cyprus	34	48	44	18
Middle of Cyprus	34	18	43	09
Weſt end of Cyprus	34	22	41	47
Rhodes	35	40	37	22
Sivia	36	05	37	17
Gozo	34	37	32	39
East end of Candia	35	04	35	32
Middle of Candia	35	08	33	56
Weſt end of Candia	35	15	32	25
Scarpanta	45	10	36	04
Caros	35	35	35	39
Langa	36	33	36	02
Stampalia	36	11	34	59
Levatta	36	38	34	54
Niza	37	02	34	31
Cavari	36	40	32	16
Palla	36	52	32	09

The Places Names.	*North Latit.* D.	M.	*Eaſt Longit.* D.	M.
Cardinals Hats	37	25	32	31
Forleonari	36	59	32	37
Millo	36	40	33	19
Goza	35	41	20	51
Samatto	35	46	19	39
Lampadoſſa	35	58	19	59
Linoſſa	36	20	20	05
Pantalaria	36	53	19	35
Kambro	37	10	18	34
Maritimo	37	52	20	02
Maſſina	38	07	23	21
Eaſt end of Sicilia	37	07	23	24
Middle of Sicilia	37	42	22	09
Weſt end of Sicilia	37	51	20	07
Uſtica	38	50	20	58
Allicur	38	45	21	47
Fallieur	38	43	22	01
Liſtallin	38	34	22	32
Lipari	38	40	22	27
Volcana	38	48	22	30
Stromballa	39	03	23	02
Foldemaſſina	38	20	23	29
Iſcia	40	46	21	36
Ponuſſa	40	40	20	32
Palmarolla	40	50	19	59
Ginnute	41	59	19	48
Gigio	41	58	19	39
Criſta	41	55	18	51
Planoſſa	42	07	18	33
Lilbo	42	31	18	36
Caprera	42	48	18	21
Gargona	43	20	18	28
North end of Corſica	42	55	17	26
Middle of Corſica	42	05	17	07
South end of Corſica	41	20	17	01
Taloro	40	56	17	19
Azanera	41	08	16	22
North end of Sardinia	41	10	17	25
Middle of Sardinia	40	06	16	54
South end of Sardinia	38	56	16	37
The Iſland of St. Pedra	39	20	16	03
Pallmade ſollo	39	11	16	05
Sarpentara	39	09	17	18
Callatta	37	57	16	28
Minorke	39	55	12	16
Mayorka	39	38	11	12
Cabrea	39	07	11	05
Collombratta	39	50	08	44
Eviſſa	39	05	09	57
Formentara	38	44	09	54

The Canary Iſlands.

The Places Names.	*North Latitud.* D.	M.	*Weſt. Longit.* D.	M.
Forta Ventura	28	12	06	28
Sanſlorotta	28	51	06	08
Allegranſſa	29	11	06	13
Grand Canary	27	43	08	31
Tenariff	28	20	09	28
Gomara	28	09	10	15
Faro	28	05	10	43
Palma	28	58	10	42
Salvagas	30	05	08	57
Dazarts	32	08	09	46
Madara	32	27	11	19
Por. Santo	33	14	10	09

The Weſtern Iſlands.

The Places Names.	*North Latitude* D.	M.	*Weſt Longit.* D.	M.
Abraoſo	37	55	29	46
Vaſo	40	30	27	28
Corvo	40	09	24	59
Flauris	39	30	24	55
Fiall	38	49	22	15
Pico	38	30	21	37
St. George	39	00	21	20
Traſſara	39	31	20	22
Gratiaſſa	39	30	21	11
Abrajo	39	52	18	53
Vajo	38	43	18	23
St. Michael	38	00	18	16
Horningo	37	25	17	36
St. Maria	37	00	17	56
Vejo	42	22	18	56
Iſland Varda	44	48	22	46
Maiden Iſland	46	30	23	36
Old Brazeel	51	03	09	56

The Sea-coast of Portugal *and* France, *from* Cales *to Callis.*

The Places Names.	*North Latitud.* D.	M.	*East Longit.* D.	M.
Cales	36	32	1	24
Cape St. Maria	36	52	0 *W.*	24
Cape St. Vincent	37	00	1	18
Lisbone	39	08	1	06
Rock *of* Lisbone	39	00	2	04
Burlings	39	43	2	28
Isles *of* Boyon	42	22	2	00
Cape Finisterre	43	10	2	55
Cape Corian	43	21	2	56
Sazarka	43	38	1	52
Cape Artingal	44	08	0	06
Cape Pinas	44	04	0 *E.*	52
Lyons	43	49	2	06
St. Andrea.	43	43	2	36
Bilbo	43	41	3	20
St. Abastian	43	40	4	19
Burdeux	45	10	5 *E.*	44
Bloy	45	28	5	19
Shorant	46	00	4	56
Rochel	46	17	4	54
Toppar	45	36	3	29
Mamosin	45	49	4	34
Olloron	45	58	4	30
St. Martins	46	16	4	29
Barges	46	30	3	54
Uss	46	44	3	20
Piller	47	04	3	22
Nants	47	45	4	15
Radon	47	55	3	33

The Coasts of Britanny.

Cardinals	47	27	2	24
Ballile	47	19	2	14
Groy	47	35	1	54
Glannats	47	33	1	34
Pennes, *or* Pennemark	47	35	1	10
Paiker	48	00	0 *W.*	01
Seames	48	04	0 E.	23
Camarita Bay	48	25	0	56
Brist	48	35	0	59
Conquer	48	45	0	19
Ushant	48	48	0	05
Island *of* Basse	49	01	1	27
Morlias	48	54	1	39
Satta Isles	49	7	2	02
St. Mallas	48	45	3	39

The Places Names.	*North Latit.* D.	M.	*East Longit.* D.	M.
Cosol	49	5	3	44
Boffin	49	19	3	42
Jarze	49	30	3	24
Sark	49	37	3	09
Garnasse	49	43	2	49
Arme	49	48	3	05
Caskats	50	7	3	09
Arderny	50	2	3	37
Cape Hag	50	4	3	52
Cape Barflaw	49	57	4	32
Rone	49	46	5	54
Saine Head	50	4	5	28
St. Vallari	50	8	5	29
Deip	50	15	6	39
Callis	51	13	7	16

The Sea-coast of England *from the* Lizard *to* Newcastle.

The Places Names.	*North Latitud.* D.	M.	*East Longit.* D.	M.
The Lizard	50	10	00	00
Falmouth	50	22	00	12
Foy	50	35	00	34
Ramhead	50	34	00	49
Plymouth	50	36	00	51
The Ediftone	50	22	00	44
The Start	50	27	1	19
Dartmouth	50	37	1	28
Torbay	50	42	1	36
The Bary	50	40	1	35
Absom Bay	50	47	1	37
Lime	50	55	2	10
Chiddock	50	57	2	14
Portland	50	50	2	36
Weymouth	51	3	2	44
Pool	51	43	3	34
Isle of Wight	50	58	4	08
Portsmouth	51	8	4	24
Shoram	51	7	4	57
Beache	50	58	5	15
Rye	51	13	6	09
Dongeness	51	9	6	15
Dover	51	25	6	32
Ripraps	51	13	6	49
The South Foreland	51	22	6	44
The Downs	51	25	6	45
Sandwich	51	27	6	33

North

The Places Names.	*North Latit.* D.	M.	*East Longit.* D.	M.
North Foreland	51	28	6	44
Margaret	51	29	6	34
Quinborow	51	30	6	01
Rocheſter	51	28	5	54
London	51	30	5	24
Graveſend	51	35	5	44
Tilbury Hope	51	38	5	54
Colcheſter	52	04	6	02
Harwich	52	11	6	27
Ipſwich	52	14	6	24
Orfordnaſs	52	20	6	35
Alborow	52	24	6	39
Yarmouth	52	45	6	42
Winterton	52	52	6	46
Cromar	53	20	6	41
Blackneſs	53	4	6	19
Wells	53	7	6	02
Lin	52	58	5	33
Boſton	53	9	5	02
Grimsbe	53	39	4	28
Hull	53	45	4	16
The Sporne	53	45	5	01
Burlington	54	00	4	28
Flamborough Head	54	8	4	35
Scarborough	54	20	4	21
Whitby	54	35	4	10
Hartlepool	54	37	3	29
Sinderland	54	4?	3	26
Shelles	55	02	3	24
Newcaſtle.	54	58	3	14

The Coaſt of Scotland.

The Places Names.	*North Latit.* D.	M.	*East Longit.* D.	M.
Berwick	55	49	2	39
Leith	56	3	2	09
Dondee	56	26	2	17
Aberdeen	57	22	2	29
Baſom Naſs	57	48	1	34
Cat Naſs	58	37	1	38
Iſles *of* Orkney	58	50	2	02
Fair Iſle	59	30	3	19
Shetland	60	22	2	54
Fair head	58	43	2 *W.*	21
Iſland Lewes	58	30	2	48
Skey Iſland	57	40	2	3

The Sea coaſt of Flanders *and* Holland *from* Callis *to the* Scaw.

The Places Names.	*North Latit.* D.	M.	*East Longit.* D.	M.
Duynkirk	51	18	7	49
Oſtend	51	30	8	29
Sluice	51	38	9	11
Zealand	51	48	9	05
The Brill	52	8	9	08
Antwerp	51	37	9	46
Rotterdam	52	5	9	48
Amſterdam	52	40	10	01
The Taſſel	53	20	10	16
The Uly	53	30	10	12
Skelling	53	35	10	14
Amaland	53	40	10	16
Embden	53	44	11	06
Breme	53	50	12	26
Hambrough	54	4	13	26
Holikeland	54	30		
Stonar	55	17	12	08
The Scaw	57	52	13	51

The Sea-Coaſts from the Lizard *to* Holy-Head.

The Places Names.	*North Latit.* D.	M.	*East Longit.* D.	M.
Lands end	50	20	0	34
Gulfe	50	11	1	22
Scilly	50	7	1	21
7 Stones	50	18	1	16
Harty Point.	51	10	0 *E.*	19
Londy	51	20	0 *W.*	3
Holms	51	26	1 *E.*	44
Briſtol	51	29	2	34
Gloceſter	52	3	2	39
Caldy	51	53	0	10
Milford	52	5	0 *W.*	6
Ramza	52	12	0	38
Studwalls	53	12	0	04
Barzs	53	13	0 *W.*	16
Weſtcheſter	53	37	01 *E.*	04
Holy-head	53	44	0	26
Iſle *of* Man	54	25	0	36

The

The Sea-coast of Ireland.

The Places Names.	*North Latitude*		*West Longit.*	
	D.	*M.*	*D.*	*M.*
Lamby	44	44	1	46
Dublin	53	32	1	56
Wexford	52	33	1	44
Waterford	52	30	2	24
Corke	42	01	2	56
Kingſail	51	52	3	08
Old Head	51	40	3	14
Mizand Head	51	28	5	21
Cow and Calf	51	42	5	42
Skillukes	52	00	6	06
Blaskos	52	15	6	11
Limbrick	53	04	4	51
Loopas Head	52	44	5	41
Gally Head	53	20	5	36
Galloway	43	40	5	16
Iſles *of* Aion	53	21	6	36
Slages	54	27	6	21
Iſles *of* Are.	55	18	5	36
Fore Head	55	38	4	56
Fair Foreland	55	35	2	36

The Sea-coaſt of Heland Iſland.

The Places Names.	*North Latit.*		*Weſt Longit.*	
	D.	*M.*	*D.*	*M.*
Mage Naſs	61	32	2	51
Merchant Foreland	63	52	11	42
Horn	63	42	10	16
Silly	64	50	9	56
Bargafar Point	65	27	7	01
Long Naſs	66	26	7	36
Grimſa	66	42	9	20
Marza	67	8	9	42
Rage Point	66	40	12	00
Fair Foreland	65	40	14	53
Snow Hill	65	11	14	50
Rook Point	64	00	14	09
Weſt main Iſles	63	17	12	53
Gammat Iſles	63	48	15	06
Grimes Hole.	63	23	15	46

The Sea-coaſt in the Sound.

The Places Names.	*North Latitud.*		*Eaſt Longit.*	
	D.	*M.*	*D.*	*M.*
Lizol	57	35	14	9
Anall	57	8	14	41
Elſen-nore	56	40	15	21
Copenhaven	56	17	15	18
Mooan	55	41	15	29
Witmond	55	20	16	32
Iſmond	55	20	16	44
Burnthom	56	00	17	40
Erthholm	56	10	17	38
Gathe ſand	56	15	22	03
Farro Sound	58	48	21	53
Gotland	58	20	21	22
Heda	55	53	21	29
Dormamel	56	55	23	44
Dines Naſs	58	22	23	55
Righa	57	50	26	25
Runen	58	38	25	14
Parun	58	52	26	54
Shorham	58	58	26	30
Wile	59	6	25	6
Ardenbro	59	5	24	6
Dagaratt	59	44	23	55
Ogſholm	59	58	24	32
Norgin	60	10	25	14
Eaſt Rand	60	12	28	41
Wibro	61	16	30	00
Wakato	61	16	29	42
Patting	61	00	28	45
Burga	61	2	27	14
Roſtbrugh	61	3	25	04
Abbo	61	8	23	28
Buſhoers	60	9	21	54
Stockholm	58	49	20	6
Frouenboro	58	48	18	16
Stickholm	58	23	18	24
Yaffro	58	10	18	58
Fuland	57	42	19	12
Chiping	56	53	18	27
Faſtinboro	56	2	15	49
Scarlet Iſland	56	40	16	02
Elſinbro	56	46	16	00
Cape Cole	57	00	15	36
Nading	57	53	15	04
Holm Sound	59	8	13	44
Mordo	58	37	12	2
Walle Sound	58	25	11	40
Long Sound	59	7	12	54

From

From Naze *of* Norway *to* Archangel.

The Places Names.	*North Latitude* D.	M.	*East Longit.* D.	M.
The Naze *of* Norway	58	00	10	26
Stave Angor	58	57	9	44
Out Shers	59	7	8	30
Bomal	59	31	9	04
Harla Iſland	60	24	9	02
Katts Naſs	61	54	8	06
Swin	62	40	9	10
Gallee	62	52	9	46
Gripo	63	40	11	26
Roſs Illes	67	1	13	30
Werro	67	38	13	52
Lowſat	68	30	14	40
Zanham	70	28	18	32
Aſſumption	71	7	20	38
North Cape	71	22	22	6
Skitanboro	70	56	24	2
Iſland Kilding	68	54	26	16
Cape Race	65	49	29	28
Cape Gallant	67	11	28	56
Cape Crace	65	17	28	54
Fox Naze	64	12	26	31
Archangel	63	22	26	46

The Coaſt of Greenland.

The Places Names.	*North Latitude* D.	M.	*East Longit.* D.	M.
Cherri *Iſland*	74	34	20	32
Hope *Iſland*	76	13	23	16
Hopeleſs Iſles	77	00	22	54
Nageo Point	77	10	23	38
Duckus Cone	77	45	22	54
Cape Blande	78	25	23	26
Helis Sound	79	27	24	19
Point Lookout	76	25	20	18
Horn Sound	77	7	20	00
Ball Sound	77	34	20	3
Foe Sound	78	38	20	45
Bear Sound	79	15	19	55
Black Point	78	32	18	34
Cape Cold	79	00	17	56
Fair Foreland	79	15	19	29

The Coaſt of the North-Weſt Diſcovery.

The Places Names.	*North Latitud.* D.	M.	*Weſt. Longit.* D.	M.
Cape Farewel	59	00	41	50
Sir Thomas Smith's Bay	79	10	79	50
Botton's Iſles	60	20	62	50
Bell Iſle	51	2	48	44

Where the Table is begun, on the Coaſt of Terra Nova.

The *Difference* of *Longitude* between two Places, is an *Arch* of the *Æquinoctial* intercepted between the two *Meridians*, paſſing by thoſe Places.

The *Latitude* of a Place is the *Diſtance* of the *Zenith*, or the *Vertical Point* thereof from the *Æquator*, or the *Height* of the *Pole* elevated above the *Horizon*. You have been ſhewed ſeveral ways already, for the finding the *Poles* Elevation above the *Horizon*: but this *Rule* will not be impertinent in this Place, being not named before, which is by the *Stars* thus, and is proper to obſerve the *Latitude* on the Land.

You muſt obſerve ſome *Fixed Star* in the *Heavens*, which is near the *Pole*, and that never ſets in that *Region*: Thus, you may obſerve the leaſt and alſo the greateſt *Altitude*, of the ſaid *Star*, when he doth come to the *Meridian* under the *Pole* and alſo above the *Pole*; which done, you muſt add the leaſt *Altitude* to the greateſt, and take the half thereof which will be the Elevation of the *Pole*, or *Latitude* of the Place.

An *Example* whereof may be this. The firſt *Star* of the three in the *Tail* of the *Great Bear*, in his leaſt *Altitude*, obſerved at *Briſtol*, is 10 deg. 59 min. and the greateſt *Altitude* of the ſame, when he is above the *Pole*, is found to be 91. d. 59 m. (or 88 deg. 1 min. from the South part of the *Horizon*) both which Numbers being added together, do make 102 deg. 58 min. The half of that ſame is 51 deg. 29 min. the *Lattitude* or *Elevation* of the *Pole* at *Briſtol*.

You may take notice, I begin the *Longitude* at the *Meridian* of the moſt *Southern* parts of *England*, the *Lizard*, and encreaſe it on each ſide of that *Meridian*, from thence

thence to 180deg. both *Eaſtward* and *Weſtward*; therefore you muſt note, That by theſe Tables all Places that lie to the *Eaſtward* of the *Meridian* of the *Lizard*, are ſaid to be in *Eaſt Longitude*; and all Places, on the *Weſt* ſide of the *Meridian* of the *Lizard* in *Weſt Longitude*.

Therefore a *Ship* being in *Eaſt Longitude*, ſailing to the *Eaſtward*, ſhe encreaſeth her *Longitude*; but ſailing to the *Weſtward*, it decreaſeth. And likewiſe if a Ship be to the *Weſtward* of the *Lizard*, that is in *Weſt Longitude*, and ſaileth to the *Weſtward*, the *Longitude* encreaſeth; but ſailing to the *Eaſtward*, the *Longitude* decreaſeth.

You may take notice, I took my firſt *Latitude* and *Longitude* from the *Northern* parts of *New-found-land*, to the *Weſtward* at *Cape Homblanto*, near *Bell-Iſle*, and ſo have coaſted all round the Bay of *Mexico*, and taken the *Weſt India* Iſlands in the way, and ſo round the *Coaſt* by *Brazil*, and through the Straits of *Magellane* to *Nova Albion*, and from thence to the *Eaſt India*, firſt the Iſlands, and then the *Main Land*, and back by *Cape Bon Eſprance*, and round the Coaſt of *Guinney* and *Barbary* down from *Tangire* and *Tooke* in the *Canary* Iſlands, and *Weſtward Iſlands*, and ſo along the Coaſt from *Cales* to *Callis*, and from the *Lizard* to *New-Caſtle*, and from thence along the Coaſt of *Scotland* to *Skey Iſland*, and along the Coaſt from *Calis* to the *Scaw*, and along the Coaſt from the *Lizard* to the Iſle of *Man*, and round the Coaſt of *Ireland* to the *Sea-coaſt* of *Iſeland*, and ſo from the *Scaw* round the *Sound*, by the *Naſe* of *Norway* to *Archangel*, and about by the Sea-coaſt of *Green-land*, by the *North-weſt Diſcovery*, to the Coaſt of *New-found-land*, where firſt I began; whereby you may ſee I have traced a Path, or coaſted round to the moſt Chief Harbours, Head-lands, and Iſlands in the World. And ſo I ſhall conclude with theſe Verſes in Mr. *Philips*'s *Preface*.

When Drake *and* Candiſh *Sail'd the World about,*
And many Heroes *found new* Countries *out,*
To Britains *Glory, and their laſting Fame:*
Were we like-minded, we might do the ſame.

The End of the Fourth Book.

STURMY's
MATHEMATICAL AND Practical Arts.

The Fifth BOOK.

SHEWING

The ART of SURVEYING of LAND by the MARINERS AZIMUTH or AMPLITUDE-COMPASS; By which you may SURVEY and PLOT with eaſe and delight all manner of *Grounds*, either ſmall Incloſures, Champions, Plains, Wood-Lands, or any other Uneven Grounds.

AND ALSO

How to take the *Plot* of a whole *Town*; and to be ſatisfied whether his *Plot* will Cloſe, before you begin to *Protract* the ſame.

ALSO

The ART of GAGING all ſorts of Veſſels, as Cubical and Cylindrical Veſſels; alſo Pipes, Hogſheads, and Barrels; and to meaſure Cask that are part out. And alſo to meaſure Brewers Tuns, whether Oval or Conical Veſſels, or Brewers Coppers.

And likewiſe,

How to meaſure exactly all kind of Plain Superficies, as Walls, Timber-Work, Roofs of Houſes, Tyling, Board, and Glaſs, and Wainſcot, Pavement, and the like; As alſo Timber and Stone; And of meaſuring of *Ships*.

The ART of GUNNERY,

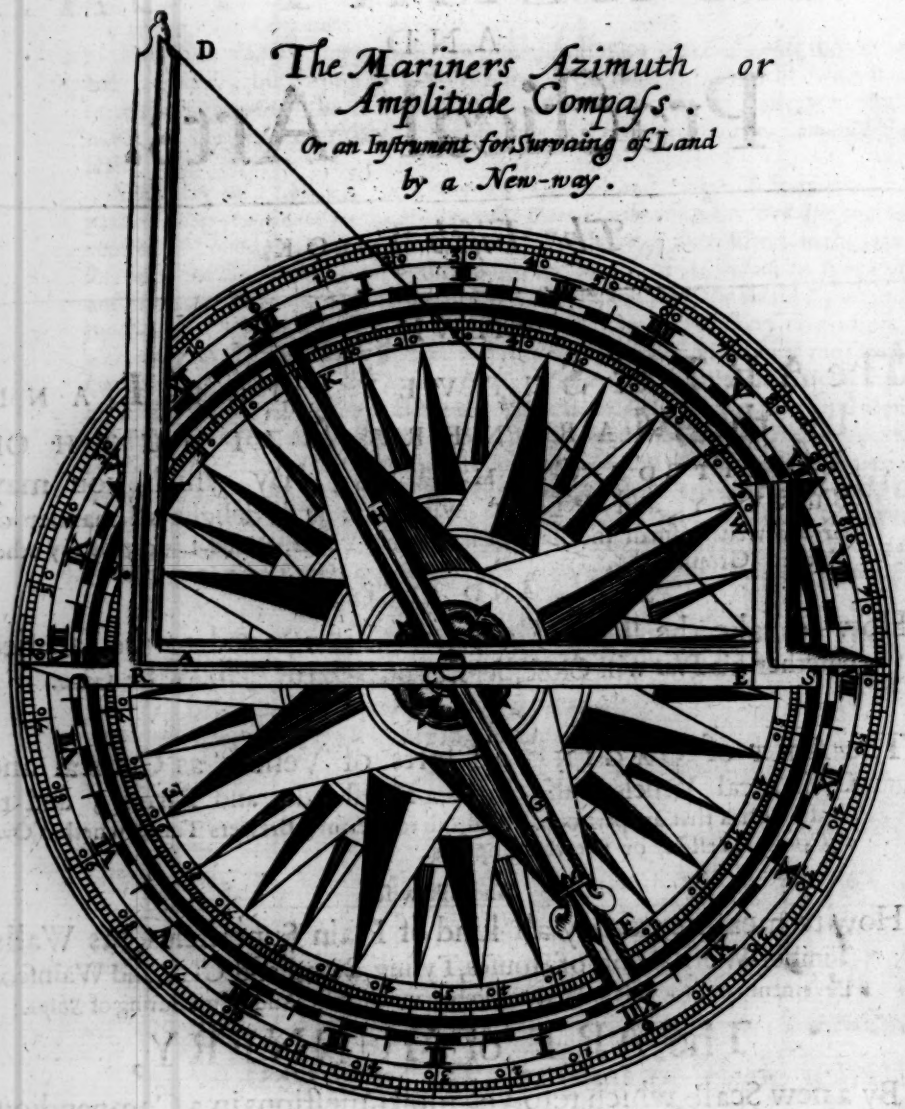
By a new Scale, which reſolves moſt Queſtions in a Compendious manner. With divers excellent Concluſions, all reſolved, both *Arithmetical*, *Geometrical*, and *Inſtrumental*, and by *Tables*; Being framed both with, and without the help of *Arithmetick*.

Likewiſe,

Divers ſorts of Artificial FIRE-WORKS, both for Recreation, and alſo for *Sea* and *Land* Service.

By Capt. *SAMUEL STURMY*.

LONDON,
Printed by *Andrew Clark*, Anno Dom. M. DC. LXXVI.



The Mariners Azimuth or Amplitude Compaſs.

Or an Inſtrument for Survaing of Land by a New-way.

The AUTHOR to his Fifth BOOK.

HEre comes a *Critick*, cloſe thy Page,
Thou art no Subject for this Age:
And Cenſure oftentimes you know
Will ſtrike the *Dove*, and ſpare the *Crow*.
But hold; thy Guilt does not require
That thou ſhouldſt lurk, or yet retire.
Be open as the Eye of Noon,
And let the Dogs bark 'gainſt the Moon.
Thou haſt no Luſtre of thy own
But what's deriv'd from *Art* alone.
Fear not, thy *Art* inſtructed Page
May either pleaſe, or teach the Age.

To my much Honoured Patron,

Sir *JOHN SHAW* Knight and Baronet:

And to the reſt of the Honourable

FARMERS

OF

HIS MAJESTIES CUSTOMS,

Sir *John Wolſtenholme*, Sir *Robert Vyner* Knights and Baronets; Sir *Edmond Turner* Knight, *Edward Backwel*, and *Francis Millington* Eſquires;

External, Internal, and Eternal Happineſs be wiſhed.

HONOURABLE SIRS,

MAN had at the firſt, and ſo have all Souls before their entrance into the Body, an Explicite Methodical Knowledge; but they are no ſooner Veſſell'd, but that Liberty is loſt, and nothing remains but a Vaſt confuſed Notion of the Creature. Thus had I only a Capacity without Power, and a Will to do that which was far enough above me. In this perplexity I ſtudied ſeveral Arts, and put them into Practice: For my own ſullen Fate had forc'd me to ſeveral Courſes of Life; but I find not one hitherto which ends not in Surfeits or Satiety, and all

the Fortunes of this Life are Follies. Thus I rambled over all theſe Mathematical Inventions or Sciences. Wherefore (Honourable Sirs) *I having Compoſed, out of my poor Studies, this* Miſcellany, *and conſidering there was nothing in it more uſeful for your Service than the Art of* Surveying, *knowing that you beſtow Surveyors Offices upon many, but divers may be wanting in the Knowledge and Labour of the Art; my ſelf once enjoyed both in your Honours Service, by the kind thankful Remembrance of my much Honoured* Patron: *but Envy ſoon eclipſed my Office without deſert, and left me only my Art: Therefore (as St.* Paul *ſaith in another Caſe)* I will wait with patience until my Change will come; *and in the mean time I am your Honours humble Servant, and humbly proſtrate theſe my poor Labours at your Honours Feet, begging your Patronage thereof, knowing, that there was never any thing ſo well contrived by the Wit of Man, that hath not been ſubject to the Cenſure and Miſconſtruction of the Envious: Nor do I at this time (in the Production of this) expect Immunity from the Cenſorious Criticks of this preſent Age; yet for ſuch was this Work never intended, but only for the Judicious, Whoſe candid Cenſures I dare abide: But yet not without Labour and difficulty can Books have paſſage into the World; therefore to the end the placid Fruits of theſe my Labours (now grown up among the wild Grapes of the Field) may be cheriſhed and preſerved from the tur-*

turbulent Stormes of diſcontented Spirits, it now being come to its Maturity and Perfection, muſt humbly implore the Protection of ſome Honourable Perſons to defend it: and being well aſſured (Sirs) *of your Honours moſt Heroick and Candid Diſpoſitions, I humbly caſt this into the Arms of your Humanity for Shelter and Protection; not doubting but that your refulgent Rayes ſhining thereon, will be ſufficient to annihilate and diſpel the moſt dark and miſty Clouds aſcending our* Horizon; *which will not a little ſtrengthen both my preſent and future Undertakings for the* Publick Good, *and excite the* Author *to a grateful Acknowledgement of your* Memorable Virtues, *and to echo forth the Praiſes due to your* Names *and* Eminencies. *All that I have endeavoured is to profit others, and to make my diligent and ſtudious* Reader *and* Practitioner *able to benefit his* Country (*which*, certes, *is no more than the* Common Law *of* Humanity *requires at all our hands*) *and not like ſome, to bury their Treaſures in the* Aſhes *of* Oblivion; *which puts me in mind of that Excellent Saying of* Tullie, Non nobis ſolum nati ſumus. *Wherefore* (Honourable Sirs) *I have endeavoured in as plain and ſuccinct a Method as I could imagine, to lay down the Art of* Surveying, *a New way, by the* Mariners Sea-Compaſs, *which is the beſt* Inſtrument *for their Uſe and Purpoſe, it agreeing ſo near their* Traverſe Rules *at Sea, that there is very little difference.*

And

And likewiſe I have ſhewed the Sea-men the Land-man's Art *of* Surveying *and* Gauging *all ſorts of Veſſels, and plain Superficies and Solids; the* Art *of* Gunnery, Artificial Fireworks, *and* Aſtronomy, *in the following Book; and ſo furniſhed the whole* Work *with ſuch* Theorems *and* Problems, *Geometrically, Inſtrumentally, and by Calculation, as are moſt neceſſary and ſubſervient thereunto: And therefore* (Honourable Sirs) *you being able to protect it, I moſt humbly commit it to your gracious Protection, reſting,*

Sirs,

St. Georges, *or the* Pill,
neer Briſtol, *Mar.* 25.
Anno 1669.

Your Honours moſt humble

and faithful Servant,

SAMUEL STURMY.

The ART of Surveying of Land By the SEA-COMPASS:

The Description of the COMPASS, STAFF, and CHAIN.

The Fifth Book.

CHAP. I.



Have been all this while shewing the *Mariner*, How to describe and make his own *Instruments*, and the use thereof in *Navigation*; I am also willing to shew him the use there may be made of his *Sea-Compass*, commonly called the *Azimuth*, or *Amplitude-Compass*, which all ingenious *Mariners* carry to *Sea*.

This *Compass* requires but little description, it being so well known to all Sea-men; for it is the same in a manner as they Steer the Ship by. The *Chart* within the Box is divided as you see in this Figure, each quarter into 90 Degrees, beginning at North and South, numbred East and Westward; on the Glass there is a Brass Circle, and Diameter, that goes over the Center of the *Compass-Chart*, the Brass Circle may be about $7\frac{1}{2}$ Inches Diameter, and about $\frac{4}{10}$ of an inch broad; The outward Circle is divided into 360 Degrees by 90 Degrees in each Quarter, as the former was; the Figure makes all plain to the meanest capacity; The inward Circle is the Hours and Quarters, and they are numbred as you see in the Figure.

In the Diameter F G H K there is a right Line drawn in the midst, as G H, and at each end is two slits of an inch and an half long, as F G and H K; which are cut right in the middle with a small Lute-string, by which in taking any Angle, you must be sure to set the North Point right under the one; and the South Point under the other; and then turn the *Index* (that is riveted to the Center at C) to the Object, and look through the sights that stand upon it; and when you find you see it plainly, and have made a good observation of the Angle, look what Degrees the edge of the *Index* cuts, and upon what Quarter of the *Compass*: and that number of Degrees is the Angle from the *Meridian*.

The sights that stand perpendicular on the *Index* are 1 inch and $\frac{1}{4}$ long; the further sight hath a Wire that goeth through the midst thereof, by which we cut the

Object: that ſight next the eye hath only a ſlit, through which you muſt ſee the Wire cut the Object you look at when you make any Obſervation.

Betwixt the two ſights is a right Line drawn through the midſt, and at the further ſight is faſtned a perpendicular of Braſs with a right Line through the midſt as R D: this perpendicular is faſtned with two ſmall Braſs Screws at M and O to the further ſight, and at D is a hole where is faſtned a Silk thread put through a ſmall hole in the Eye-ſight at S, and faſtned with a wooden pin.

The Uſe of the *Azimuth-Compaſs.*

And this is for to take the Sun's *Azimuth* at any time of the day, by turning the Eye-ſight to the Sun; and the ſlits over the North and South point of the *Chart* (as before directed;) and when the ſhadow made by the Thread D S falls upon the Line S A in the midſt of the *Index*, and on the perpendicular Line R D; then on that inſtant take the Sun's Altitude by a *Quadrant* or *Staff*, and note it down: and likewiſe the Degrees cut by the *Index* at the eye-end, and that is the Sun's Magnetical *Azimuth* at that time. If you unſcrew the perpendicular from the ſight, then you have the *Compaſs* ready to take an Amplitude at the Sun's Riſing or Setting: but more of that in the following Treatiſe, when we ſhall touch upon *Aſtronomy*.

The *Amplitude Compaſs.*

When you make uſe of the *Compaſs* for Surveying of Land, you have a Braſs ſocket ſcrewed faſt to the bottom of the inward Box that holds the *Chard*: In that ſocket you put the head of your three-legged *Surveying-Staff* with a ſmall ſcrew on the ſide to faſten it to the head, that it may not ſtir when the *Compaſs* is ſet North and South as before directed; then you may turn the *Index* and ſights to what object you pleaſe, and be ſure of your Angle from the Meridian, if your *Chard* be good, and the Needle well touched and placed. Thoſe that make them ſhould have a ſpecial care of that; and that the points of the Needle be faſtned and cemented together, ſo that they do not ſtir, as I have ſeen in many *Charts* careleſly made. I would adviſe all Ingenious *Mariners* to make a conſtant practice of taking obſervation of the Sun's *Azimuth*, and Steer a Courſe, and make allowance accordingly, by a Meridian Compaſs, as hath been ſhewed elſewhere; and then this *Inſtrument* will come to the Truth, as well as a *Needle* of greater charge, or the *Plain Table*, or the *Theodolite*, *Circumferenter*, or *Peracter*. And yet I cannot but highly commend theſe *Inſtruments* as very uſeful. Neither dare I reject as uſeleſs, either the *Topographical Inſtrument* and *Croſs-Staff* of Mr. *Digges*, the *Familiar Staff* of Mr. *John Blagrave*, the *Geodetical Staff*, and *Topographical Glaſs* of Mr. *Arthur Hopton*, the *Sector Croſs-Staff*, and the *Pandoron* of Mr. *George Atwel*, or any other witty Invention which hath been deviſed for the Exact Plotting, and Speedy Meaſuration of all manner of *Superficies*, as *Land*, and the like. But in regard the Authors have in their own Works, to their exceeding Commendation, deſcribed the Making and Uſe of theſaid *Inſtruments*, I ſhall ſay no more.

How the *Needles* of the *Compaſs* muſt be ſet.

Of the Devices of *Inſtruments.*

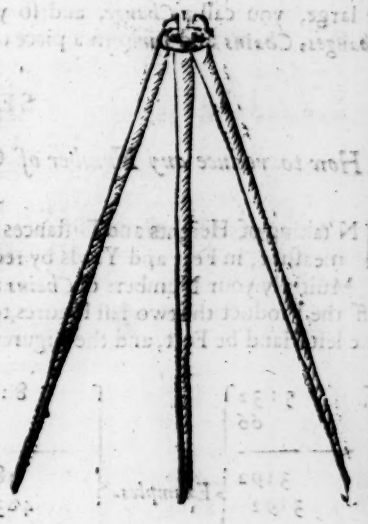
And for the *Mariners Compaſs* in a manner to do the ſame things for the *Surveying* of *Land*, I hope will be well taken and accepted of all ingenious *Mariners*, for whoſe ſake I take this paines.

Let the Glaſs over the *Chard* be as clear as poſſibly you can get it.

The

The Figure of the *Staff* is plain, it needs no further deſcription: it is to be had at any *Inſtrument-Makers*. The *Staff*.

Of Chains, *the ſeveral ſorts thereof.*



Of *Chains* there are ſeveral ſorts as namely, *Foot-Chains*, each *Link* containing a Foot or 12 Inches; ſo the whole *Pole* or *Perch* will contain 16½ *Links* or Feet according to the Statute *Pole*.

The *Chains* now uſed, and in moſt eſteem among *Surveyors* are Three: as, Firſt, Mr. *Rathborn's*, which had every *Perch* divided into 100 Links: and that of Mr. *Gunter's*, which had 4 *Perches* or *Poles* divided into 100 Links: So that each Link of Mr. *Gunter's Chain* is as long as Four of Mr. *Rathborn's*. And this year Mr. *Wing* hath deſcribed a *Chain* of 20 Links in a *Perch*, for the more ready uſe in his Art of *Surveying*; Therefore when we have taken the *Angles*, and Plotted a piece of ground, we will ſhew how to know the contents thereof in *Acres*, *Roods*, and *Perch* by the two laſt *Chains*.

SECT. I.

Mr. *Gunter's* Chain.

MAſter *Gunter's Chain* is a *Chain* moſt uſed amongſt the *Surveyors* of this Age, and is always made to contain 4 *Poles*, and each *Pole* 25 Links and each Link 7 Inches $\frac{92}{100}$ of an Inch. In meaſuring with this *Chain* you are to take notice of only *Chains* and *Links*; ſaying, ſuch a Line meaſured by the *Chain* contains 64 *Chains* 45 *Links*, or thus diſtinguiſhed 64. 45.

Now for the ready counting of the *Links*; at every *Perch* let there be two Curtain-Rings faſtned, and one Ring at every five *Links*: ſo you may readily count the Rings at either end. If the Ingenious *Mariner* wants a *Chain*, he may mark a ſix Thred-line, as before directed, with Red Cloth and White for diſtinction, or bits of Leather, as we mark our *Dipſey Line*; and be ſure to ſtretch him well firſt; or if you can, let it be a *Top gallant Brace* half worn; then meaſure it exactly, and mark him as before directed, and you may meaſure any piece of *Land* or *Plantation*, or any diſtance, as well in dry weather, as with a *Chain*, without ſenſible Errour.

SECT. II.

Cautions to be uſed, and to be obſerved in the uſe of any Chain.

WHen you have occaſion to meaſure large diſtances, you may by chance miſtake or miſs a *Chain* or two in keeping your account, which will breed a conſiderable Error; and alſo in meaſuring of diſtances, in going along by a Hedge ſide you can hardly keep your *Inſtrument-Chain* and mark in a right line; and therefore the diſtance will be more than in reality it is. For avoiding theſe miſtakes, you ought to provide ten ſmall ſticks, which let him that leadeth the *Chain*, carry in his Hand before; and at the end of every one of thoſe *Chains*, ſtick one of theſe Sticks

or

or Arrows into the Ground, which let him that followeth take up; ſo going on until the whole number of Sticks be ſpent, and then you may conclude you have meaſured Ten *Chains* without further trouble: and theſe Ten *Chains*, if the diſtance be large, you call a *Change*, and ſo you may denominate every large diſtance by *Changes*, *Chains* and *Links* in a piece of Paper where you keep the account.

SECT. III.

How to reduce any Number of Chains *and* Links *into* Feet *and* Yards.

IN taking of Heights and Diſtances hereafter taught, it is neceſſary to give your meaſure, in Feet and Yards by reducing of your *Chains* and *Links*, thus:

Multiply your Numbers of *Chains* and *Links*, as one whole Number by 66, cutting off the Product the two laſt Figures towards the right Hand; ſo ſhall the Figures to the left Hand be Feet, and the Figures cut off ſhall be 100 parts of a Foot.

5 : 32			8 : 06	
66			66	
3192			4836	
3192	*Examples.*		4836	
351, 12			531, 96	

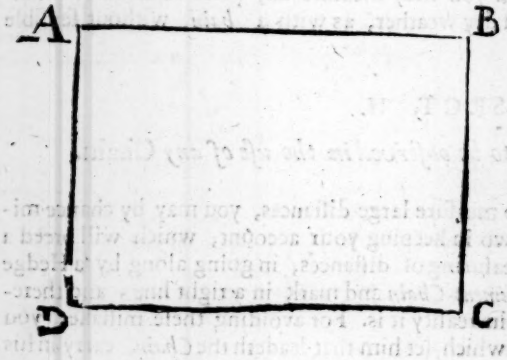
Let it be required to know how many Feet are contained in 5 *Chains*, 32 Links. Set down the *Chains* and *Links* with a *Colon* (:) thus; and theſe Multiplied by 66, the ſum will be 351 Feet and $\frac{12}{100}$ parts of a Feet as thus you ſee it ſtand 351 : 12. This is the Rule by Mr. *Gunter's Chain.*

If you divide the Feet by 3, the *Quotient* will be 117 Yards. Now if you have leſs than 10 *Links*, as 6, you muſt always remember to put (0) before the 6, and Multiply the number as you ſee in the laſt Example.

SECT. IV.

How to caſt up the Content of any piece of Land *in* Acres, Roods, *and* Perches *by Mr.* Gunter's Chain.

BY a Statute made the 33 of *Edward* the Firſt, an *Acre* of Ground ought to contain 160 ſquare *Perches*, and every *Rood* of Land 40 ſquare *Perches*, and every *Perch* contains 16 $\frac{1}{2}$ Foot; and 4 *Perches*, or *Poles*, in breadth, and 40 in length makes an *Acre*: which multiplied together is 160, Half an *Acre* is 80, a Quarter 40 ſquare *Perches*.



Suppoſe the Figure ABCD were a ſquare piece of Ground (as the *Marſh* of *Briſtol*,) and were 15 *Chain* 16 *Links* every way: Then to find how many *Acres*, *Roods* and *Perches* are in it, do thus: Square the ſides, that is, Multiply one in the other, and cut off the five laſt Figures to the right hand, and that before is *Acres*: what remains multiply by 4 (for 4 *Roods* makes an *Acre*) and cut off five Figures as before, and the *Comma*: is *Roods*; and that which remains, multiply by 40 the number

number of *Perch* in a *Rood*, and cut off five *Figures* to the *right hand* of the *Product*; and in like manner you have the odd *Perches*. This *Example* will make all clear and plain.

So you will find 15 *Chains*, 16 *Links* multiplied together, as before directed, will produce 22, 98256: the 5 laſt *Figures* cut off to the *left hand*, there remains before the *Comma* 22, which is 22 *Acres* and the 5 *Figures* multiplied by 4, the *Product* is 393024: 5 *Figures* cut off on the *left hand*, the remainder is 3 *Roods*; and the 5 laſt *Figures* multiplied by 40, cutting off 5 *Figures*, and the reſt will be 37 *Perch*.

	15 : 16
	15 : 16
	96
	1516
	7580
	1516
Acres 22 [	98256
	4
Roods 3 [	93024
	40
Perch 37 [	20960

By the Line of Numbers.

Extend the *Compaſſes* on the *Line* of *Numbers* (on the *Scale* of *Scales*) from 10 unto the *ſide* of the *Square* AB 15 *Ch.* 16 *Lin.* the ſame extent will reach from 15 *Ch.* 16 *Lin.* to 22 *Acres* $\frac{2}{10}$.

SECT. V.

How to meaſure *a* Long Square *Piece of* Ground *by a* Chain *of* 20 Links *to a* Perch, *according to Mr.* Wing.

MAſter *Wing* in his *Art* of *Surveying*, in the 113 Page hath deſcribed a *Chain* of 20 *Links* in a *Perch*, which is ſomewhat more ready, if you will reckon the *Land* in *Perches* for ſmall parcels of *Land*.

Suppoſe a piece of *Land* be in *length* 36 *Perches* and 16 *Links*, and in the *breadth* 3 *Perches* 2 *Links*; By this *Chain* I deſire to know the *Contents* thereof, having 20 *Links* in a *Perch*, I deſire to perform the *operation* in a *Decimal* way; Count by half the number of *Links*, and then the *Sums* will ſtand thus; and cutting off 2 *Figures*, and you have for the *Content* of the *piece* of *Ground* 114 *Perches* $\frac{8}{100}$ parts. But I would adviſe the Practitioner in greater parcels of *Land*, to follow Mr. *Gunter's Chain*, *Surveyors* all generally making uſe of it; therefore, for further Uſe of Mr. *Wing's Chain*, I refer you to his Book of the *Art* of *Surveying*.

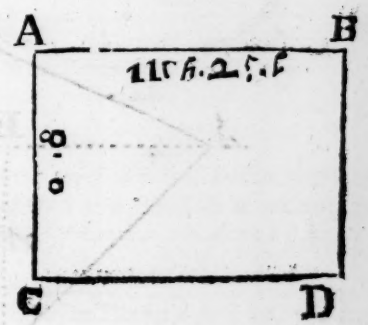
368
31
368
1104
114: 08

SECT. VI.

To meaſure a Long Square piece *of Ground.*

LEt the *piece* of Ground be ABCD whoſe length AB is 11 *Chains* 25 *Links*, (or 45 *Perch*,) and his *breadth* AC 8 *Chains*, (or 32 *Perch*.)

Multiply one by the other, as before in the laſt *Example*, directed by Mr. *Gunter's Chain*; and you will find the *Content* of the Ground to be 9 *Acres* juſt.



By

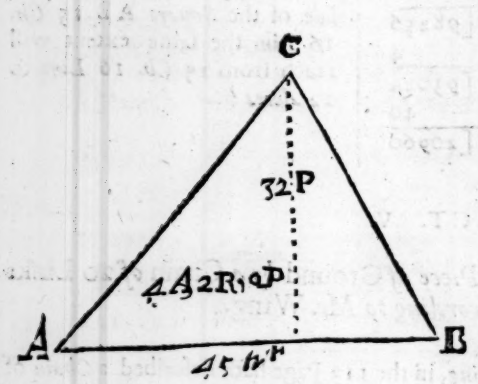
By the Line of Numbers.

1125
800
9|00000

Extend the *Compaſſes* from the □ *Center*, which is at 160 *Perch* unto the length A B 45, and the ſame diſtance will reach from the breadth A C 32 *Perch*, to 9 *Acres*.

SECT. VII.

To meaſure a Triangular piece *of Ground.*



1125
400
4|50000
4
2|00000
4 *Acr.* 2 *Ro.*

Suppoſe the *Baſe* of a *Triangular* piece of Ground A B, whoſe meaſure is 11 *Chains* 25 *Links*, or 45 *Perch*, and the perpendicular C D 32 *Perch*, or 8 *Chains*; Take the half thereof, and multiply the *Baſe* by ½ the Perpendicular, it will produce the *Content* of the *Triangle* to be 4 *Acres*, 2 *Roods*, 0 *Perch*.

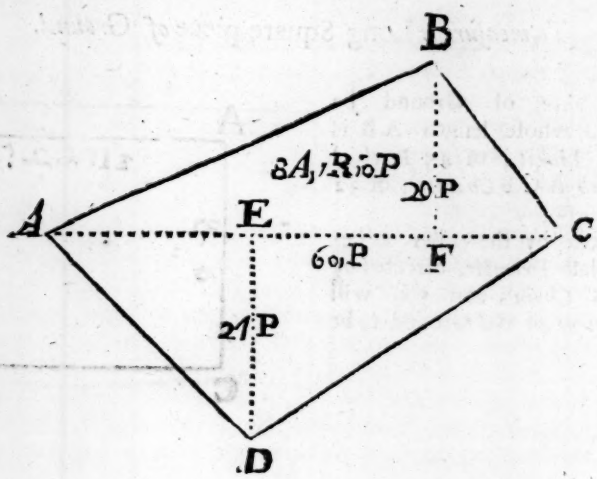
By the Line of Numbers.

Extend the *Compaſſes* from the △ *Center*, which is at 320--- unto the *Baſe* A B---45, the ſame extent will reach from the Perpendicular C D 32 unto the quantity of *Acres*, which is 4 *A*. $\frac{5}{10}$ as before.

SECT. VIII.

To meaſure a piece of Ground of four unequal ſides, called a Trapezia.

LEt the Ground given be A, B, C, D; after you have taken the *Angles* with your *Compaſs*, and noted them down in a piece of Paper or *Field-Book*, (as ſhall be ſhewn in the following Diſcourſe) you muſt Protract or lay down the *Figure* as I do, this, by a *Scale* of equal parts of 10, 15, 20, 25, or 30 *parts*



in

in an *Inch*; (I have laid down all that follow by 20 parts or *Perch* in an Inch) then draw the *Diagonal Line* A C, and with your Compasses take the distance A C, and apply it to your Scale of 20 *Perch* to an Inch; and you will find it 60 *Perch*, or 15 *Chain*; and then if you let fall the perpendiculars B F and D E, and measure them in the like manner, you will find by your Scale B F 20 *Perch*, or 5 *Chain*, and D E 24 *Perch*, or 6 *Chain*.

In respect the *Base* is common to both the *Triangles*: You may therefore add the two perpendiculars together 20, and 24, the sum will be 44, the half thereof is 22 *Perch*. This number being multiplied by the length of the *Common Base* A C, 60 *Perch*, giveth 1320 *Perch*, that divided by 160, gives the *Contents* of the *Trapezia* or piece of Ground to be 8 *Acres*, 1 *Rood*, 0 *Perch*. You might have multiplied half the *Base* A C 30 by the sum of the two perpendiculars 44, and it gives you the same as before.

By the Line of Numbers.

Extend the Compasses from the △ *Center* at 320
to half the length of the *Diagonal* A C —— 30

The same will reach from the *Sum* of the perpendicular 44, to the quantity of *Acres*, which is 8 $\frac{2}{1}\frac{1}{0}$ *Acres*.

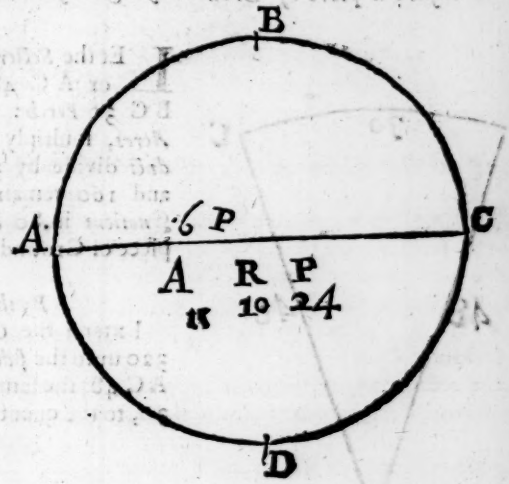
After this manner you may measure a piece of Ground of 5, 6, 7, 8, or any number of *Sides*, by bringing it into *Triangles* and *Trapezias*, as shall be shewn hereafter.

60
22
120
120
1320
5 (4)
232(0) (8
160
44
30
1320

SECT. IX.

To measure a piece of Ground in the form of a Circle.

MUltiply the Diameter into it self, and multiply that Product by 11, and divide by 14, the *Quotient* is the *Area* of the *Circle*. *Example.* In this *Circle* A B C D let the Diameter thereof be 56 *Perches*, *Feet*, or *Inches*, which multiplied in it self giveth 3136. This number multiplied by 11, gives 34496, which being divided by 14, the *Quotient* will be 2464, that is the *Area* of the *Circle*.



How many *Poles*, *Feet*, or *square Inches*, are in any *Circle* whatsoever, you may know also by this *Rule*; First, If you know the *Diameter*, and would find the *Circumference*, say, as 7 to 22, so the *Diameter* 56 to the *Circumference* 176; Or if you know the *Circumference*, and would find the *Diameter*, say, as 22 to 7, so is the *Circumference* 176, to the *Diameter* 56.

7:22:56
22
112
112
1232
54
2232[176
777
22:7:176
7
1232
xx
zz
xzzz (56
zzz
z
88
28
704
176
2464
z
28(6
246(4 (13
166(0
z

The Diameter *and* Circumference *being thus known, the Rule to find the* Content *is this.*

The *Diameter* being 56 *Perch*, and the *Circumference* 176, the half of each of these multiplied together, and divided by 160, will give the *Content*, viz. *Acres* 15, *Roods* 1, *Perch* 24.

By the Line of Numbers.

Extend the *Compasses* from O *Center* at 203, unto the *Diameter* A C 56, the same distance will reach again from 56 to the quantity of *Acres* 15 $\frac{4}{1}\frac{1}{0}$.

Though the ordinary proportion of 7 to 22 is somewhat too much; yet it is but about 1 in 2000, which will breed no great difference in these Questions.

SECT. X.

To measure a piece of Ground in the form of an Ellipsis, commonly called an Oval.

Multiply 40 one by the other. 00
120
Multi ply 491
1200
10800
4890
A. 5 [89200
4
R. 3 [50800
40
Per. 22 [72000



IN the *Oval* A B C D, let the length be given 40 *Perch, Feet,* or *Inches*; and D B 30 of the same measure: Then to find the *Quantity* in *Perch, Feet,* or *Inches*; (if you work by the same Denomination of *Feet* and *Inches*, as I do of *Perches*.)

Multiply A C 40 by D C 30, the *Product* multiply by 491, and from that *Product* cut off 5 Figures, the *Contents* will be 5 *Acres*, 3 *Roods*, 22 *Perch*, as in the Margin.

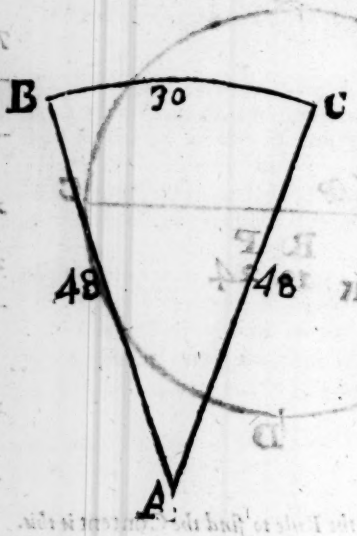
By the Line of Numbers.

Extend the *Compasses* from the 0 *Center* in the *Line* at 203 7 to the length of the *Oval* A C 40, the same *distance* will reach from the *breadth* D B 30 unto the *Contents* in *Acres*, 5 *Acres* $\frac{9}{10}$ *fere*.

SECT. XI.

To measure a piece of Ground lying in form of a Sector *of a* Circle.

Mult. 48
30
00
144
1440
Div. by 320
(1)
x(6)
244 0) (4
32



LEt the *Sector* be A B C, whose *sides* is A B, or A C 48 *Perch*, and the *Arch* thereof B G 30 *Perch*: Then to find the *Contents* in *Acres*, multiply A B 48 by B C 30, the *Product* divide by 320, the *Quotient* is 4 *Acres*, and 160 remains, which divided by 2 the *Quotient* is 80 *Perch*; So the *Contents* of this piece of Ground is 4 *Acres*, 2 *Rood*, 0 *Perch*.

By the Line of Numbers.

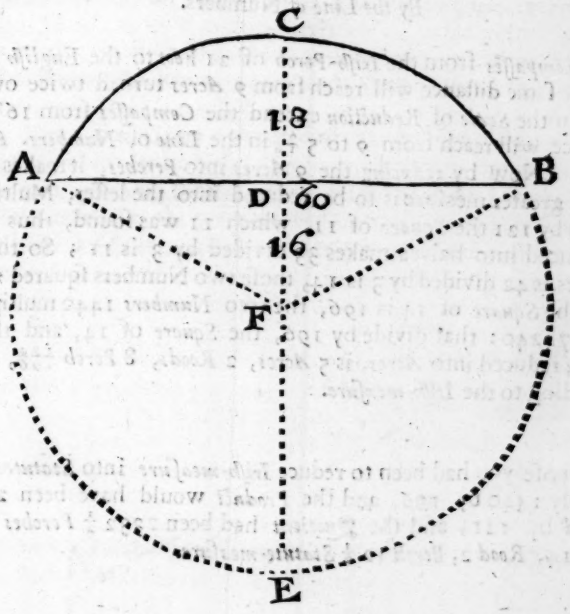
Extend the *Compasses* from the Δ *Center* at 320 unto the *side*, (or *Semidiameter*) A B or A C 48, the same distance will reach from B C 30, to the quantity of *Acres* 4 and $\frac{1}{10}$.

SECT. XII.

SECT. XII.

To meaſure a Piece of Ground being the Segment *of a* Circle.

LEt the *Segment* be repreſented by A B C, in which A B is 60 *Perch*, and D C 18 *Perch*. Firſt, find the *Diameter* of the Circle, thus, As D C 18, is to the half of A B (that is A D) 30: So is A D 30 to D E 50. To D E 50 add D C 18, the ſum is 68 the *Diameter* C E.



Then find the *Area* of the Circle A C B E by *Sect.* 9. which will be 3633 *Perch*.

Then find the length of the Arch A C B in *degrees* and *Minutes*, thus, As C F B 4, to A D 30: So is the Radius to the Sine of 161 *degr.* 55 *min.* which doubled is 123 *deg.* 50 *min.* or 123 *deg.* $\frac{5}{6}$.

Then find the *Area* of the Sector A F B C thus: As 360 *degr.* to 123 *degr.* $\frac{5}{6}$, ſo is 3633 the *Area* of the Circle, to 1249 *Perch* the *Area* of the Sector.

Then find the Content of the Triangle A F B by *Sect.* 7. which is 480 *Perch*.

Then ſubſtract the *Area* of the *Triangle* 480, from the *Area* of the Sector 1249 the Remainder 769 *Perch* is the *Content* of the *Segment* A C B; which reduced to *Acres* makes 4 *Acres*, 3 *Rood*, 9 *Perch*

Note if it be required to find the Content of the *Segment* A E B, which is bigger than a Semicircle, you muſt add the *Area* of the *Triangle* A F B to the *Area* of the Sector A E B F, and the ſum is the Content of the *Segment*.

SECT. XIII.

A Piece of Ground being measured by the Statute-Perch *of* 16½ *Feet, To know how many* Acres *it is, it being measured by a* Perch *of* 21 *Foot, which is the* Irish Perch.

Sta. Per. 16½
Irish 33 [11
Per. 33
21
42
2
42(14
33
The *Square* of 11 is 121. and of 14: 196
196:121:1440
121
1440
2880
1440
174240
(½)
29 (0)
297 (9)
2724
9246(2)
274240 888, 196
29666
299
2
3'8)
88 8[5
16(0
quar.
8(8(2--8 *P.*
4(0
5 *Ac.* 2. *Q.* 8. *P.*
Perch : 196/1440
196
8640
12960
1440
282240
282240
121
2332 62/121
3
7(9
2333(2(14
2660
2

Example. A *Piece* of *Ground* being found 9 *Acres* by the *Statute-Perch* of 16½ *Foot*; and you would know how many it is by the *Irish Perch* of 21 *Foot*.

By the Line of Numbers.

Extend the *Compasses* from the *Irish-Perch* of 21 *Foot* to the *English Statute-Perch* of 16½ *Foot*, the same distance will reach from 9 *Acres* turned twice over unto 5 6/10 *Acre, fere*: Or in the *Scale* of *Reduction* extend the *Compasses* from 16½ *Foot* to 21, the same distance will reach from 9 to 5 6/10 in the *Line* of *Numbers*. And so of any other measure. Now by *reducing* the 9 *Acres* into *Perches*, it makes 1440 *Perch*; and because the greater measure is to be reduced into the lesser, Multiply the given Quantity 1440 by 121 the *Square* of 11, which 11 was found, thus 16½ being a *Fraction*, it reduced into halves makes 33 divided by 3 is 11; So the *Irish-Perch* 21 *Foot* in halves is 42 divided by 3 is 14, those two Numbers squared *viz.* the square of 11 is 121, the *Square* of 14 is 196, the two *Numbers* 1440 multiplied by 121, the *Product* is 174240: that divide by 196, the *Square* of 14, and the *Quotient* is 888 192/196 *Perch*, reduced into *Acres*, is 5 *Acres*, 2 *Roods*, 8 *Perch* 192/196, that is almost 9 *Perch*, according to the *Irish-measure*.

Suppose you had been to reduce *Irish-measure* into *Statute-measure*, then multiply 1440 by 196, and the *Product* would have been 282240: that *divided* by 121; and the *Quotient* had been 2332 6/11 *Perches* which makes *Acres* 14, *Rood* 2, *Perch* 12 6/11 *Statute-measure*.

By the Line of Numbers.

Extend the *Compasses* in the *Scale* of *Reduction* from the number of *Feet* in *Customary measure* 21 *Foot* the *Irish Perch* to the *Statute Perch* 16 foot ½: the same will reach from 9 *Acres Irish* in the *Line* of *Numbers* to 14 *Acres* ½, *Statute-measure*.

Or if you extend the *Compasses* from 21 in the *Line* of *Numbers* to 16 and ½; the extent turned twice over from 9, will fall upon 14 and ½ *Acres*, and a little more.

So that if you remember in all sorts of measure to *reduce* your *Fraction* into the same Denomination, and seek out the least proportionable terms, by *squaring* these terms as before directed, you have a *Rule* that serves for all sorts of *Customary measure* whatsoever.

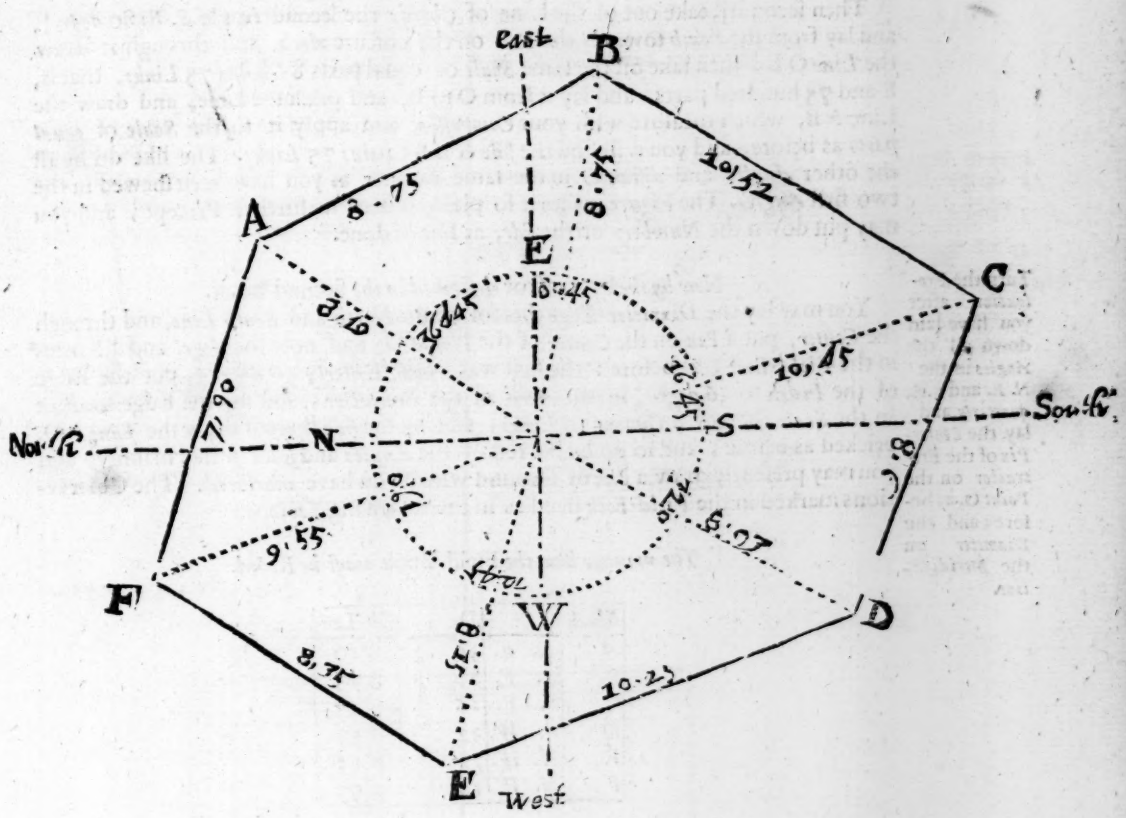
CHAP. II.

CHAP. II.

How to take the Plot of a Field at one Station in the middle thereof by the Azimuth Compaſs.

BEfore you go into the *Field*, you muſt Rule a piece of Paper in 8 *Columns* as you ſee the Figure following in this Chapter, which is called a *Field-Book*. When you come into the *Field*, firſt place Marks at the ſeveral *Angles* of the *Field*, as at A, B, C, D, E, F, in the following *Figure*; then make choice of ſome convenient place about the middle thereof at O, to fix your *Compaſs*, that you may ſee all the Marks; and be ſure the *Braſs-Diameter* and *Slits*, before deſcribed, be ſet directly over the *Meridian* or *North* and *South Line* of the *Chard*, and there fixed.

This done, direct your *Sights* to your firſt Marks at A, obſerving what *Degree* the *Index* cutteth, which let be *N E 36 Degr.* $\frac{1}{4}$; This you muſt note down in your *Field-Book* in 1 and 2 *Column* thereof, as you ſee in the *Book* it is ſet down; then meaſure the diſtance from O the place of the *Compaſs* to A your firſt Mark, which let contain 8 *Chains*, 10 *Links*, which muſt be placed in the 3 and 4 *Column* of your *Field-Book*.



Then

Then direct your *Sights* to B the second Mark, and note the *Degrees* cut by the *Index*, which let be *South Easterly* 80 *Degrees* ¼, and the *distance* 8 *Chains* 75 *Links*. You must put down in the *Field-Book*, as before; First, the Letter B; Secondly, the Angle with the *Meridian* cut by the *Index South Easterly* 80 *Degr.* ¼ in the third *Column*; then 8 *Chains* 75 *Links* in the fourth, as you may see in the *Book*; then direct your *Sights* to C your third Mark, and note the *Degrees* cut by the *Index*, which let be *S. E.* 16 *Degr.* , and the distance O C 10 *Chains* 45 *Links*, put the same down in the *Field-Book* likewise, as before directed; then direct your *Sights* to D, and note the *Degrees* cut by the *Index*, which let be *S. W.* 32 *degr.* the distance O D, 8 *Chains* 53 *Links*, note it down in the *Book*, as before. Then direct your *Sights* to E, the *Index* cutting 72 *degr.* ¼ *North-Westerly*; and the distance O E 8 *Chains* 15 *Links*: They must be noted in the *Book* as the rest are. Lastly, direct your *Sights* to F your last Mark, the Edge of the *Index* cutting in the upper *Brass Circle N. W.* 18 *degr.* the distance O F 9 *Chains* 55 *Links*; then will the Observation stand in the *Field-Book*, as in the following *Table* or *Figure*.

Then by a *Line* of *Chords*, or by the *Protractor* you may presently Protract the exact Figure of the *Field* upon Paper thus; By a Line of *Chords*; take 60 *degr.* and draw the *Circle*. Secondly, draw the *Meridian* Line of *North* and *South*, and the *Line* of *East* and *West*. Thirdly, in your first Observation the *degr.* cut by the *Index* was 36 *degr.* ¼ *N. E.* Therefore take 36 *degr.* ¼ off the Line of *Chords*, and lay from the *Meridian Line* from M to N. Fourthly, the distance O A was found 8 *Chains* 10 *Links*; take with your *Compasses* off any *Scale* of equal parts, 8 and ⅒ (that stands for 8 *Chains* 10 *Links*) lay this distance from O to A, and draw the *prick'd Line* O A.

Then secondly, take out of the Line of *Chords* the second Angle *S. E.* 80 *degr.* ¼, and lay from the *South* towards the *East* on the obscure *Arch*, and through it draw the *Line* O B; then take off the same *Scale* of equal parts 8 *Chains* 75 *Links*, that is, 8 and 75 hundred parts, and lay it from O to B, and prick the Line, and draw the Line A B, which measure with your *Compasses*, and apply it to the *Scale* of *equal parts* as before, and you will find the *side* A B 8 *Chains* 75 *Links*. The like do by all the other *Angles* and *distances* in the same manner as you have been shewed in the two first *Angles*. The *Figure* makes it so plain, it need no further Precept; and you may put down the *Numbers* on the *side*, as I have done.

Turn the *Protractor* after you have laid down all the *Angles* in the *N. E.* and *S. E.* *quarterly*, and lay the *Center-Pin* of the *Protractor* on the *Point* O, as before; and the *Diameter* on the *Meridian-line*.

Now by the Protractor *described in the* Second Book.

You may lay the *Diameter-Edge* thereof on the *North* and *South Line*, and through the *Center*, put a *Pin* on the *Center* of the *Plot* at O, and note the *degr.* and distances in the *Field-Book*, as before: the first was *North Easterly* 36 *degr.* ¼, put the Edge of the *Index* to 36 *degr.* ¼ in the *Arch* of the *Protractor*; and by the Edge account in the *Scale* thereof 8 *Chains* 10 *Links*; and by the *side* thereof draw the *Line* A O, pricked as before; and so do by the rest of the *Angles* and *sides* in like manner, and you may presently draw a *Plot* of Ground which you have *measured*. The Observations marked in the *Field-Book* stand as in the following *Table*.

The manner how the Field-Book *must be Ruled.*

Mark.			*D.*		*Ch*	*Lin.*
A	*N.*	*E.*	36	¼	08	10
B	*S.*	*E.*	80	¼	8	75
C	*S.*	*E.*	16	¼	10	45
D	*S.*	*W.*	32		8	53
E	*N.*	*W.*	72	¼	8	15
F	*N.*	*W.*	18		9	55

CHAP.

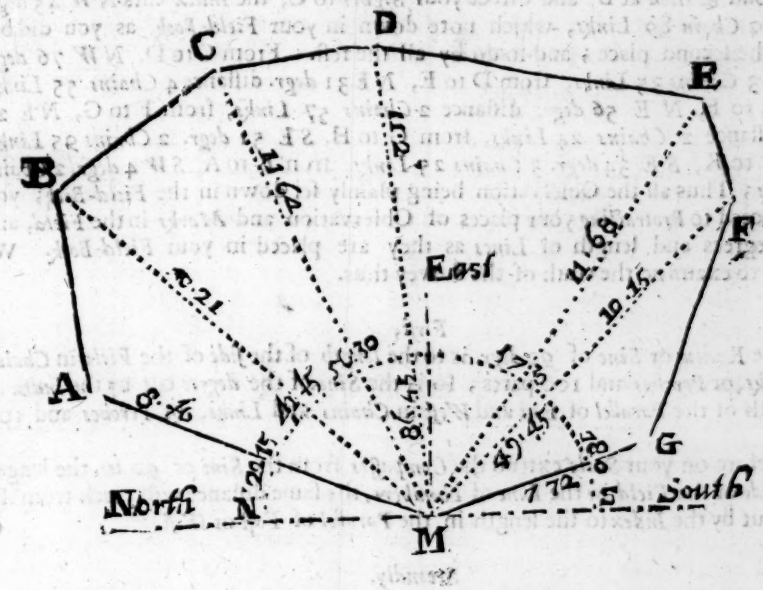
CHAP. III.

How to take the Plot *of a Field at one Station in one of the* Angles *by the* Sea-Compass.

IN the Figure of the *Field* following, place your *Compass* at M, set you *Brass-Diameter* right over the North and South points; then first direct your Sights to A, which let be supposed to be 22 *degr.* ¼. N. E. which note in your *Field-Book*, as before; then measuring the distance with your *Chain* M A, which let be 8 *Chains* 46 *Links*, which place in your *Field-Book* according to former directions.

Secondly, Direct your Sights to B, the *degree* cut off by the *Index*, suppose 42 *degr.* ¼. and suppose the distance measured to be M B 10 *Chains* 21 *Links*, and put them down also in the *Field-Book*.

Thirdly, Direct your Sights to C, the *degr.* cut is 66 *degr.* ½, and the distance M C 11 *Chains* 64 *Links*, put these in your *Field-Book* also, as before; and in the same manner you must deal with the other marks D, and E, and F, and G; and so having them all in the *Field-Book*, they will stand as followeth:



The Figure of the Field-Book.

M		Deg.	M.	C.	L.	North.	outh.	East.	West.
A	N E	22	¼	8	46				
B	N E	42	¼	10	21				
C	N E	66	½	11	64				
D	N E	86	¾	11	23				
E	S E	57	¼	11	68				
F	S E	49	¼	10	15				
G	S E	18		7	72				

CHAP.

CHAP. IV.

How to measure any Piece of Ground, be it never so Irregular; *And how to reduce the* Sides *into* Triangles *or* Trapezias, *and to cast up the* Content *thereof in* Acres *and* Perches.

Suppose you were to measure a Piece of Ground, Wood, or *Marsh*, or any place whatsoever, by your Compass and a Line marked as the 4 *Pole-Chain* before described in the first *Chapter*; and if you cannot see all the *Angles* by reason of the bigness thereof, then you may measure round about by the sides thereof, as in this Figure following, and the Observations made in the Field are set down in the *Field-Book* following, which is so plain, that it needs no further precept.

Suppose you made your first Observation at A in the *Field* in the following *Figure*, (the *Compass* being rectified as before directed) you direct your *Sights* along the Hedg to the Mark in the corner at B, and the *Index* cuts 54 *degr.* from the *Southwestwards*, and the distance is 5 *Chains* 12 *Links*, which set down in your *Field Book* thus: A B *S W* 54 *degr.* distance 5 *Chain.* 12 *Links*; Then make your second *Station* at B, and direct your *Sights* to C, the *Index* cuts *N W* 45 *degr.* distance 2 *Chain* 89 *Links*, which note down in your *Field-Book*, as you did before in the second place; and so do by all the rest. From C to D, *N W* 76 *degr.* distance 3 *Chains* 35 *Links*, from D to E, *N E* 31 *degr.* distance 4 *Chains* 55 *Links*, from E to F, *N E* 56 *degr.* distance 2 *Chains* 57 *Links*, from F to G, *N E* 21 *degr.* distance 2 *Chains* 24 *Links*, from G to H, *S E* 51 *degr.* 2 *Chains* 95 *Links*, from H to K, *S E* 34 *degr.* 3 *Chains* 25 *Links*, from K to A, *S W* 4 *degr.* 2 *Chains* 95 *Links*; Thus all the Observation being plainly set down in the *Field-Book*; you may proceed to *Protracting* your places of Observation and *Marks* in the *Field*, and your degrees and length of *Lines* as they are placed in your *Field-Book*. We proceed to examine the truth of the Survey thus.

How to know if the *Sides* be rightly *measured* before you go out of the *Field*, and *Protract* the *Plat* thereof.

First,

As the *Radius* or *Sine* of 90 *degr.* is to the *length* of the *side* of the *Field* in *Chains* and *Links*, or *Perches* and 100 parts; so is the *Sine* of the *degree* cut by the *Index* to the length of the *Parallel* of *East* and *West* in *Chains* and *Links*, or *Perches* and 100 parts.

Therefore on your *Scale* extend the *Compasses* from the *Sine* of 90 to the length of the *side* of the *Field* in the *Line* of *Numbers*, the same distance will reach from the *degrees* cut by the *Index* to the length in the *Parallel* of *East* or *West*.

Secondly.

As the *Radius* or *Sine* of 90 *degrees* to the length of the *side* of the *Field* in *Chains* and *Links*, or *Perch* and 100 parts; so is the *Sine Complement* of the *degrees* cut by the *Index* to the length of the *Meridian* either *North* or *South* in *Chains*, or *Links*, or *Perch*, or 100 parts.

Wherefore extend the *Compasses* from the *Sine* of 90 *degrees* to the length of the *side* of the *Field* in the *Line* of *Numbers*; the same distance will reach from the *Sine Complement* of the *degrees* cut by the *Index* to the length *North* or *South* in the *Meridian*.

So that you see the 4 last *Columns* in the *Field-Book* are noted *North* and *South*, *East* and *West*.

Now to know by the *Chains* and *Links*, the first Observation from A to B, is *S W* 54 *degr.* and the distance A B is 5 *Chains* 12 *Links*; therefore by the last *Rule* extend the *Compasses* from 90 *deg.* to 5 *Chains* 12 *Links* in the *Line* of *Numbers*, that distance will

will reach from 54 *degr.* cut by the *Index* to 4 *Chains* 14 *Links* in the *Line* of Numbers, which is the diſtance in the *Parallel* of *Weſt*, and alſo the ſame extent will reach from the *Complement* of 54 *degr.* which is 36 *degr.* to 2 *Chains* 97 *Links* in the *Line* of Numbers, which is the diſtance in the *Meridian South*, and put it in the *South Column* of your *Field-Book*, as you did 4 *Chains* 14 *Links* in the *Column* of *Weſt*; and ſo you may do with the reſt of the Obſervations.

Or you may convert your *Chain* and *Links* into *Perches* and 100 *parts* of a *Perch*, and then you may *Protract* in *Perch* and 100 *parts*.

Thus if you multiply the number of *Chains* found in the *ſide* by 4, (by reaſon 4 *Perches* are in a *Chain*) and if there be above 25 *Links* in the place of *Links*, divide by 25, and the *Quotient* will ſhew the odd *Perch* to be added; and what remains multiply by 4 likewiſe, the *Product* will be 100 *parts* of a *Perch*.

As for Example.

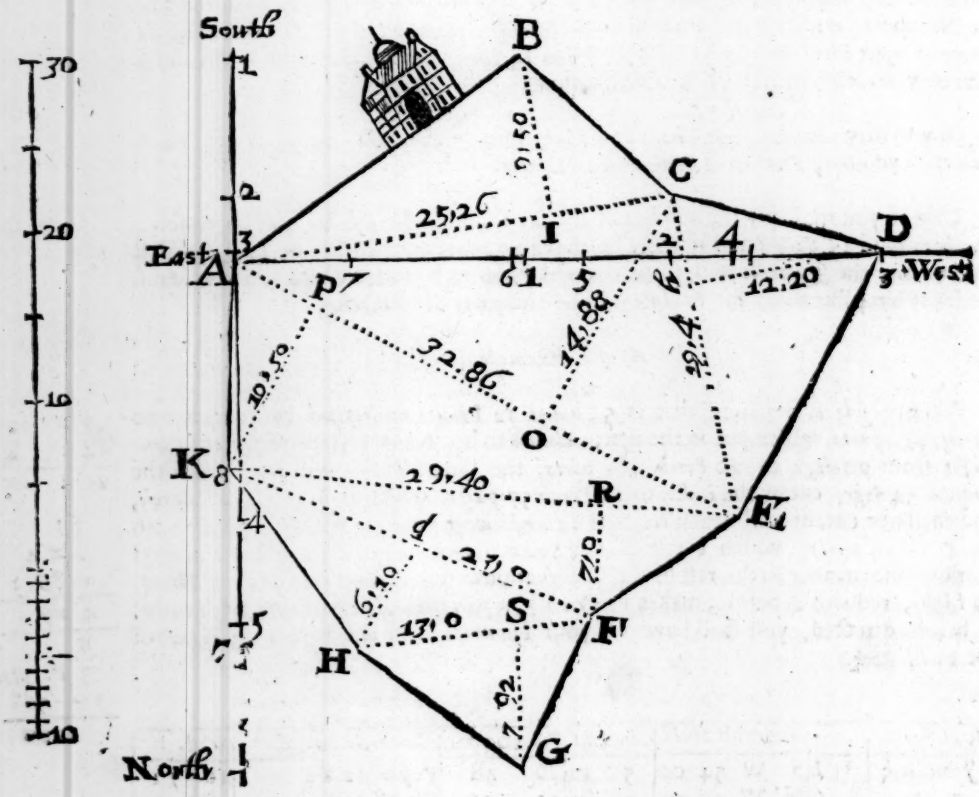
The firſt *ſide* A B his diſtance is 5 *Chains* 12 *Links*, *multiplied* by 4, makes 20 *Perch*, $\frac{48}{100}$ *parts*, which put in the next *Column* to it; Now if you extend the *Compaſſes* from 90 *degr.* to 20 *Perch* $\frac{48}{100}$ *parts*, the ſame *diſtance* will reach from the *Sine* of 54 *degr.* cut by the *Index* to 16 *Perch* 57 *parts*, which is in the *Weſt Column*, and the ſame extent will reach from the *Complement* 54 *degr.* which is 36 *degr.* to 12 *Perch*, 4 *parts*, which I put in the *South Column*; and by the ſame *Rule* I work in like manner in the reſt of the Obſervations. The ſecond ſide B C is 2 *Chains* 89 *Links*, reduced as before, makes 11 *Perch* $\frac{56}{100}$ *parts*; and ſo working with them, as before directed, you ſhall have all your *Numbers* as in the following *Figure* of the *Field-Book*.

5 : 12
4 : 4
20 : 48

(1
2 4
2-89(3
4 25
8
3 P. pts.
11--56
100

Houſes Names.		*Angl.with Merid.*	*Ch.*	*Lin.*	*Pol.*	100 *pts.*	*North.*	*South.*	*Eaſt.*	*Weſt.*	
John Cook 2.42.	*A* *B*	S W 54 00	5	12	20	48	*P. pts.*	12 84		16 57	1
	B *C*	N W 45 00	2	89	11	56	8 18			8 81	2
	G *D*	N W 76 00	3	35	13	40	3 25			13 00	3
	D *E*	N E 31 00	4	55	18	20	15 60		9 37		4
	E *F*	N E 56 00	2	67	10	68	5 97		8 85		5
	F *G*	N E 21 00	2	24	8	96	8 37		3 24		6
	G *H*	S E 51 00	2	95	11	80		7 42	9 16		7
	H *K*	S E 34 00	3	25	13	00		10 77	7 27		8
	K *A*	S W 4 00	2	95	11	80		11 77		0 83	9
						The Sum	41 37	42 09	37 89	38 58	

Now if there be any Houſes by the *Hedge-ſide*, make a mark in your *Field-Book*, in that *Angle*, how many *Chains* or *Perch* from the place you obſerve, and ſo inſert it into your *Plot*.



As for Example.

Now to draw the *Plot* by the *Protractor.*

There is a *Houſe* in the firſt *ſide* A B, at 2 *Chains* 42 *Links*, therefore put it down in your *Book*, with the Man's Name that owes the *Houſe*, *John Cook*, or the like; and if any *Houſe*, *Church*, or *Caſtle*, be in the *middle*, take the *Angle* thereof from any *Point*, and meaſure the diſtance, and note it in your *Book*, and enter it into your *Plot*, as I have done this *Houſe*. By theſe *Rules* you may completely take a whole *Pariſh*, *Plantation*, or *Iſland*: Now if you draw a *Plot* by the *Protractor* deſcribed in the *Book* of *Inſtruments*, you muſt rule your *Paper* or *Parchment* with an obſcure *Meridian Line*, and *Parallel Lines* about 1 Inch and ½ aſunder; and put the Center-Pin upon any *Point*, and turn the ſide of the *Protractor* parallel to the *Meridians*, and look in the *Field-book* for the *Angle*, and put the Edge of the *Index* to the *degrees*, and count the *Perch* on the *Index*, there make a Mark with your *Pin* for the ſecond place, and draw a *Line* from that place by the Edge of the *Ruler* for the ſide of the *Hedge* or *Field.*

As for Example.

Suppoſe you were to draw the ſide A B in the *Plot* with your *Protractor*, lay the *Diameter-Edge* of your *Protractor* to the *Meridian Line*; then in the oppoſite *Degree* and *Quarter* which in this *Example* is *N E*: I put the Foot of the *Index* to 54 *degrees*, and from the *Center*, the Edge points *S W* 54 *degr.* then number the *Chains*, and *Links*, or 20 *Perch* 42 *parts*, and from that *Number* to the *Center* draw a *Line* by the *Edge* thereof, and you have the *ſide* A B; by this *Rule* you may gain all the reſt.

Now

Now we ſhall proceed to find the juſt Quantity or Content of this Piece of Ground.

WE have ſhewed in the fore-going Chapter, how to *Meaſure* the *Geometrical Square*, the *Parallelogram*, the *Triangle*, *Trapezium*, the *Circle*, and the like. Now we will ſhew you how to caſt up the *Content* of any field whatſoever. Suppoſe the fore-going Figure A B C D E F G H K being drawn or Protracted by a *Scale* of 10 *Perch* in an *Inch*, and the *Content* thereof is required. Now becauſe it is an irregular *Plot*, neither in the form of a *Square*, *Parallelogram*, *Trapezium*, nor *Triangle*; therefore I reduce the main Body of the *Field* into the *Trapezium* A C E K, and the *reſidue* of it into 5 *Triangles*, as A B C, C D E, E F K, F H K, and F G H.

Now to know the juſt Quantity of *Acres*, *Roods*, and *Perches* the *Field* contains, I firſt *meaſure* the *Trapezium* A C E K, taking with my *Compaſſes* the *length* of the Perpendicular C O, and apply it to my *Scale* of 10 *Perch* in an *Inch*, and find it 14 *Perch* $\frac{88}{100}$ *parts*; and likewiſe the Perpendicular K P, and find it 10 *Perches*, 50 *parts*, which I add together, and they make 25 *Perches*, 38 *parts*, which I Multiply in half the *Baſe* A E 16 : 43, and the *Product* is 416 : 99 34 : Therefore if you cut off 4 *Figures* to the *right-hand*, you will have the *Contents* of the *Trapezium* 416 *Perch*, and $\frac{99}{100}$ *parts*, rejecting the two laſt *Figures*.

In like manner for the *Triangle* A B C, I multiply half the Perpendicular : 4 : 75 by the whole *Baſe* 25 *Perch* 26 *parts*, or the whole Perpendicular by half the *Baſe*, as before : it is all one, and the *Product* is the *Content* of the *Triangle* A B C 119 *Perch* 98 *parts* : and ſo likewiſe for the *Triangle* C D E, multiply half the *Baſe* 9 *Perch* 52 by 12 *Perch*, 20 the Perpendicular, and the *Product* is 116 *Perch* 14 : is the *Contents* of that *Triangle*. Likewiſe in the *Triangle* E F K, the length of the Perpendicular F R is 7 *Perch* : 00 and the half length of the *Baſe* E K is 14 *Perch* 70, the *Product* is 102 *Perch* 90 *parts* the *Content* of that *Triangle* E F K : the 4 *Triangle* F H K the *Perpendicular* : 6 *P.* 10. half the *baſe* F K 11 *P.* 50 the *Contents* is 70 *Perch* : 15 : the 5 *Triangle* F G H the Perpendicular G S is 7 *P.* 92 and the *Baſe* F H, the half thereof is 6 *P.* 50 : multiplied together, and the *Product* is 51 P. 48 *parts* for the *Triangle* F G H.

Laſtly, I add the ſeveral ſums together, and they give the *Content* of the whole *Figure* in *Perches* and 100 *parts*.

The *Area* or *Content* of the ☞	*Trapezium*	A C E K ——	416 : 99
1	*Triangle*	A B C ——	119 : 98
2	*Triangle*	C D E ——	116 : 14
3	*Triangle*	E F K ——	102 : 90
4	*Triangle*	F H K ——	70 : 15
5	*Triangle*	F G H ——	51 : 48
The *Area* or *Content* of the whole *Field* or *Wood* is			877 *P.* 64

Which if you will reduce into *Acres*, *Roods*, and *Perches*, you muſt divide 877 *Perch* by 160, the *Quotient* ſhews the *Acres* to be 5 ; that which *remains* above 40 divide by 40, and the *Quotient* will be *Roods* 1 : and that which *remains* will be 37 *Perch*. So that the whole *Content* of the ſaid *Field* is 5 *Acres*, 1 *Rood*, 37 *Perch* and $\frac{64}{100}$ of a *Perch*. Reduce Perches into Acres, Roods, and Perches.

This is the way to caſt up the *Content* of any *Irregular Field*, by *reducing* it into *Trapeziums* and *Triangles*, and *adding* their ſeveral *Products* into one *Sum*, which ought heedfully to be regarded, it being one of the moſt material works belonging to the Practice of a *Surveyor* ; for unleſs he be perfect herein, he can never perform any Work of that nature aright. I have been brief and plain in ſhewing the *Art* of *Surveying* by the *Sea-Compaſs* ; I might have been longer, but to avoid Prolixity, I think what is writ is ſufficient : If any deſire a larger Diſcourſe, he may make uſe

of Mr. *Leybourn's Compleat Surveyor*, or Mr. *Wing's Art of Surveying*, and others that have writ at large of the Uſe of the *Plain Table*, which is the moſt eaſie and uſeful *Inſtrument* in the *Art* of *Surveying* of ſmall *Incloſures*.

CHAP. V.

How to take the Height *of any* Iſland, *or* Mountain *in the Sea by an Example made by the* Author *of the* Height *of* Teneriff.

MAny Learned Men have writ of the great incredible Height of ſeveral *Hills* and *Iſlands* in the World. For taking of the *Height* of *Iſlands* in the *Sea*, none have greater opportunities than *Sea-men*. By them may all Men be informed of the truth of ſuch like things.

It is reported of *Ariſtotle*, *Mela*, *Pliny*, and *Solinus* of the Invincible *Height* of *Athos*, a Hill in *Macedonia*, and of *Caucaſus*, and of *Caſſius* in *Syria*, and many other places: and among the reſt one of the moſt miraculous things which they have obſerved of the Mountain *Athos*, is, that it being a *Hill* ſituated in *Macedonia*, it caſts a ſhadow into the *Market-place* in *Myrrhina*, a Town in the Iſland *Lemnos*, diſtant from *Athos* 86 Miles to the *Eaſtward*. But it is no marvel it caſts ſo long a ſhadow, ſeeing by Experience of the ſhadow of a Mans Body, we find it extraordinary long at *Sun-Riſing*, or *Sun-Setting*. They report it is Higher than the Region of the Air. *Julius Scaliger* writes from other Mens Relations, that the *Pico* of *Teneriff* riſeth in height 15 Leagues, or 60 Miles: Moſt Writers agree, that it is the higheſt Mountain in the World, yet that this Iſland cannot be ſo high, ſhall appear *July*, thereby the following Obſervation.

Patricius, not content with the former Meaſure of ſixty Miles high, reaches to ſeventy Miles high; Now that any Snow is generated ſixty or ſeventy Miles above the plain Superficies of the Earth and Water, is more than ever they can perſwade any man that underſtands theſe things, ſeeing that the higheſt Vapours never ariſe by *Ptolomy* 41 Miles, and by *Eratoſthenes's* Meaſure 48 Miles above the Earth; that is, There is never no Rain, Dew, Hail, Snow, or Wind, but ſtill a clear ſerenity: But the Snow lies upon the *Pico* of *Teneriff* all the Year, except the Months of *June* and ſore it cannot be ſo high.

I have paſſed by *Teneriff* ſeveral times my ſelf; in the Year 1652 I was there in the *Caſtle-Frigot* of *London*, Captain *John Wall* Commander, and Loaded our Ship at *Garrachica*, right under the *Pico*; and ſince bound to the *Weſt-Indies* in the Year 1656, in the *Society* of *Topſam*, a Ship I had Command of, was put by *Weſterly Winds* to the *Eaſtward*, that we had ſight of the *Pico* of *Teneriff*, it bore off us *North*; about Noon I was reſolved to make Obſervations of the height thereof, to try Concluſions with my *Quadrant* of 20 *Inches Semidiameter*, deſcribed in Chapter 16 of the Second Book; and I made theſe Obſervations following: On the fifth of *May* 1656 I obſerved, and found the *Sun's* apparent *Meridian-Altitude* 81 *degr.* 48 *min.* his *Declination* 19 *degr.* 8 *min.* the *Latitude* 27 *degr.* 20 *min.* the *Latitude* of *Pico* I found formerly to be 28 *degr.* 20 *min.* difference of *Latitude* 60 *min.* which in the following *Figure* I make one half of my *Horizontal Baſe* A D; then at the ſame time obſerving the *Height* or *Altitude* of *Pico*, I found it 24 *degr.* 14 *min.* Therefore according to the *Sphericity* of this *Terreſtrial Globe*, conſiſting of the *Earth* and *Sea*, I drew the following *Figure*, the Section of the *Arch* A E F S repreſents the *Arch* of a great *Circle*, being the *Meridian*; E B a ſecond Obſervation, *N* the *North* part of the *Horizon*, *S* the *South* part, C the *Port* of *Garrachica*.

See Figure 98 in the following Schemes.

But having three days of Fair Weather, in ſight of *Pico* I made a ſecond Obſervation, and ran to it with my Ship untill I made an *Angle* with the *Pico* of 45 *degr.* 00 *min.*

00 *min.* as the *Angle* at B; and had the apparent *Meridian Altitude* of the *Sun* 81 *degr.* 29 *min.* the *Declination* 19 *degr.* 22 *min.* *Latitude* the Ship is in 27 *degr.* 53 *min.* difference of *Latitude* 27 *min.* being equal to the Height of *Pico.*

But touching the *Hypothesis*, that the Earth and Sea makes a Round Body, it is generally agreed upon by all the *Philosophers*, *Astronomers*, *Geographers*, and *Navigators* Ancient and Modern; and therefore the distance of a *degree* 60 *min.* reckoned in the Heavens by Observations of the *Sun* or *Stars* is more than sixty *English* measured *Miles* upon the Superficies of the *Earth* and *Sea*, as appears by several Experiments made by able *Artists*, but especially by the Labour and Industry of our own Country-man Mr. *Richard Norwood*, as you may see in his second Chapter of his Book, The *Sea-mans Practice*, measuring betwixt *York* and *London.* He makes it evident that 1 *degree* of a great *Circle* on the Earth, is near 367200 *Feet*, which in our *Statute-Poles* of 16 and ½ *Feet* to the *Pole* is 22254 *Poles*, and about a half, and these reduced into *Furlongs* at 40 *Poles* to a *Furlong*, makes 556 *Furlongs* and 14 *Perch*; and lastly, these reduced into *English Miles* of 8 *Furlongs* to a *Mile*, makes 69 *Miles* and 4 *Furlongs* 14 *Poles*, that is, 69 and ½ *Miles* and 14 *Poles* to 1 *degree* upon the Superficies of the Earth and Sea. And seeing a *Degree* is the 360 part of any *Circle*, equally divided in the *Circumference*; Therefore if we can find how many *Feet*, *Perches*, *Furlongs*, or *Paces*, are in a *Degree* of known measure: then can we presently resolve how many are in the *Circumference* of any *Circle* so divided on the Earth and Sea; for if there is 367200 *Feet* in one *degree* of a great *Circle* upon the Superficies of the Earth and Sea, it is evident, that if you multiply 367200 by 360 *degr.* the *Product* is 132192000 *Feet*, which reduced into *Poles*, is 8011636, and these reduced into *Furlongs*, are 200 90 *Furlongs*, and 36 *Poles*; And lastly, these reduced into *Miles*, are 250 6 *English Miles* and more for the *Circumference* of the Earth and Sea.

How to know the *Circumference* of the *Earth.*

And now if you desire the *Diameter* and *Semidiameter* of the Earth, as it is proved by *Archimedes*, That the proportion of the *Circumference* of a *Circle* is to the *Diameter* thereof almost as 22 to 7; therefore by the *Rule* of *Proportion*, multiply the *Circumference* of the Earth; namely, 132192000 by 7, and divide the *Product* 925344000 by 22, the *Quotient* is 42061091, which is the *Diameter* of the Earth in *Feet*: and the half thereof, namely, 21030545 is the *Semidiameter* of the same, or distance of the Superficies of the Earth and Sea from the *Center*, being 21 *millions* of *Feet*, and a little more; and these reduced into *Miles*, as we did the *Circumference*, shews the *Diameter* of the Earth to be 7966 *Miles*, and somewhat more: and the *distance* to the *Center* or *Semidiameter* 3983 *Miles*; and thus is found the *Circumference*, *Diameter*, and *Semidiameter* of the Earth and Sea, and also the quantity of a *degree* of the same measure in *English* measures of *Feet*, *Perch*, *Roods*, and *Miles.* Therefore if you do still retain a *degr.* in the *Heavens* to be 60 *minutes*, you may find how many *Feet* is in a *Mile* on the Earth and Water, if you divide 367200 *feet* by 60, the *Quotient* will be 6120 *feet*; which doubled, and divided by 33, the *half-feet* to a *Perch*, the *Quotient* is 370 *Perch*, and 30 foot remains: divide 370 by 40 *Perch* to a *Furlong*, and the *Quotient* is 9 *Furlongs*, and 10 *Perch* or *Poles* remains, divided by 8, the *Furlongs* in a *Mile*, the *Quotient* is 1, and 1 remains; so that a *minute* in the *Heavens* by this Experiment upon the Superficies of the Earth and Water, contains 1 *Mile*, 1 *Rood*, 10 *Perch*, and 30 *foot*; therefore my *degr.* 60 *min.* of *Latitude* at my first Observation, is found by these *Rules* to be 69 and ½ *Miles*, 14 *Perch* my distance upon the *Arch* of a great *Circle* from *Pico*: therefore working by the Rules given in the sixteenth Chapter of the second Book, the true Height of *Pico* will be found to be 31 $\frac{30}{38}$ *Miles*, and the distance from the Eye to the Top of the *Pico* will be found by the Rules in the sixteenth Chapter 76 $\frac{2}{38}$ *Miles.*

How to find the *Diameter* and distance to the *Center* of the Earth and Sea.

6120
2
2240

22
33 (3) *f.*
22240 (370
333
33
(1
37 0 9
40
R.
(1
9 (1 R.
8

The true *height* and distance from the Eye.

And working the second Observation by the same Rules, your difference of *Latitude* 27 *minutes* B D will be found to be 31 *Miles*, 2 *Furlongs*, 14 *Perch*, 19 *foot*, which is 31 $\frac{25}{38}$ *Miles*; which is almost the same Height found by the first observation: and the distance from the Eye to the Top of the *Pico* is 44 $\frac{25}{38}$ *Miles.*

By

This was inserted by *John Colſon*, Teacher of the Mathematicks in *London*.

By comparing two Obſervations made by Mr. Harry, *an ingenious Navigator, in two ſeveral Voyages, the Height of the* Pico *in* Teneriff *is* 2100 *Geometrical Paces, that is two Miles (of* 1000 *Paces) and* $\frac{1}{10}$, *and this, to all knowing men, will appear to be the truth, rather than this pretended Obſervation of the Authors, for that the Height of* Pico, *any other Mountain in the World, ſhould be* 31 *Miles is altogether incredible.*

CHAP. VI.

How to find the diſtance of a Fort, *or* Walls *of a* City, *or* Caſtle, *that you dare not approach for fear of* Gun-ſhot; *Or the breadth of a* River *or* Water, *that you cannot paſs, or meaſure over it; made by two* Stations.

Suppoſe from ſome private place, as at A, you eſpy a *Caſtle*, *Fort*, *Tree*, or place whatſoever, that you cannot approach for *Gun-ſhot*, *Marſh-grounds*, or a *River* betwixt you, or ſome other Impediment, that you cannot make your ſecond *Station* in any open place, but are forced to make it in ſome other ſecure Place at B; therefore plant your Inſtrument or Compaſs at A, and direct the Sights to C and B, take the *Quantity* of the *Angle* C A B 46 *degr.* 00 *min*, and go to B, and take the *Quantity* of the *Angle* A B C 79 *degr.* 0 *min.* then meaſure the diſtance of the two *Stations* A and B 350 fathoms.

See Figure 99 in the following Schemes. ☞

Then by a *Plain Scale*, or by the *Line* of *Sines* on the *Scale* or *Scales*, you may preſently reſolve the *diſtance*, as I do by the *Tables*.

46 *d.* 00 *m.*
79 00
125 00
180 0
125 0
55 0

As the *Sine* of 55 *degr.* 00 A C B		991336
to 350 *Fathoms*,	A B	254406
So is the *Sine* of 76 *degr.* A B C		999194
to the *diſtance*		1353600
A C 419 : $\frac{4}{10}$		262264

As the *Sine* of 55 *degr.* 00 A C B		991336
is to A B 350 *Fathoms*		254406
So is the *Sine* of 46 *degr.* 0 C A B		985693
to B C 307 $\frac{3}{10}$ *Fathoms*, the		1340099
diſtance required.		248763

SECT. I.

How to take the Breadth of a River.

Suppoſe you were to take the Breadth of a *River*, as I did at *Crocken Pill*, which runs betwixt *Glouceſter-ſhire*, and *Somerſet-ſhire*, and found the *breadth* of the *Water* upon a Spring-Tide 40 *Perch* or a *Furlong*; you muſt do it thus: Being on the River-ſide, as in the former *Figure* at E, there ſet your *Compaſs*, and obſerve ſome *mark* on the other ſide of the *Water*, as at D; then ſet a *mark* at E, and go *ſquare-wiſe*, either to the *right-hand*, or to the *left* from theſe two *marks*, ſo far, until you ſpie the *mark* D on the other ſide the *Water*, doth juſtly make an *Angle* of 45 *degr.* with the *mark* E, as here at F; then meaſure carefully F E, the diſtance of the two *Stations*, and that ſhall be equal to the *breadth* of the *River*: ſo that if F E be 10: 20: 30: 40: 50: or 100 *Poles*, or *Yards*, or *Feet*, the *breadth* is the ſame.

Or

or if you go to G, and make an *Angle* of 26 *degr.* 30 *min.* in D; then is the distance G E twice the *breadth*; but if you can get an *Angle* of 45 *degr.* for that is the best and readiest to measure the breadth.

SECT. II.

Being upon the Top of a Hill, Tower, or Steeple, to find the true distance of any Object therefrom.

TAke the *Angle* from the Top of the Tower to the Object with your Quadrant.

Example.

Let the height of the Tower, or Hill be 40 Yards, and let the *Angle* taken with your *Quadrant* be 80 *degrees*, (being 10 *degrees* under the *Line* of *Level*;) then say:

As the *Tangent Compl.* 80 *degr.* (which is 10 *d.*)	924631
is to the height 40 Yards.	160206
So is the *Radius*	10
to the distance from the foot of the *Tower* 226 $\frac{8}{10}$	235575 *Yards.*

SECT. III.

By the way of your Ship, and any two Angles *of* Position, *to find the distance of any Island, Cape, or Head-Land from you.*

YOu have been shewed how to do it with an *Angle* of 45 *degr.* already; but with a little more trouble, you may do it by any two *Angles* whatsoever.

As for example.

Suppose you are sailing full *South* from A towards B, and from A should espy *Land* at C, bearing two *Points* from you to the *Westward*, as *S S W*, or *S W* 22 *degr.* 30 *min.* and sailing still upon your Course untill you come to B, you observe the Place bears from you just four *Points*, or *S W* 45 *degrees*, which is the double of the *Angle* observed at A. If in this manner you double any *Angle*; that is, let your first *Angle* be what it will, you must Sail until you have doubled that *Number*; then you may assure your self that the distance you have sailed between A and B, is equal to the distance between B and C. So that if A B be 12 *miles*, B C is likewise 12 *miles*; and this you may do without further trouble or Calculation.

In all such Questions remember that the *Angles* at the second place of Observation, shall be either just the double, if you go nearer to the Place, or else just the Half if you go further off than the *Angle* at the first place. Therefore the first *Angle* you may take at random, no matter what it is, so you be careful to observe when you be just upon the double, or the half. See Figure 100 in the following Schemes. ☞

That this is so, is plain from 32. 1. of *Euclid.* which is, that the outward *Angle* of any *Triangle* is equal to the two inward opposite *Angles*; *viz.* the outward *Angle* D B C is equal to the two inward opposite *Angles* B A C and A C B: And therefore if the outward *Angle* D B C be the double of the inward *Angle* B A C, then it follows that the two inward *Angles* are equal to each other, and that their opposite sides A B and B C are equal to each other; by the 7. 1. of *Euclid.*

CHAP. VII.

How to take the Diſtance of divers places one from the other, remote from you, according to their true Situation in Plano, *and to make a Map thereof by the* Compaſs *and* Plain-Scale.

THe *Problem* ſerveth chiefly to deſcribe upon Paper or Parchment all the moſt Eminent and Remarkable places in a Country, Town, or City, whereby a *Map* thereof may be exactly made by help of a *Table* of Obſervations following, as with a little Practice you may ſoon perceive.

Upon ſome high Piece of Ground make choice of two *Stations* as A and P, from whence you may plainly diſcern all the principal Places which you intend to deſcribe in your Map; then at A fix your *Compaſs*, and turn the *Index* about to P; and ſuppoſe A and P bear one off the other *North* and *South*, as you ſee marked with the Letters *N* and *S:* and then direct your *Sights* to the ſeveral Marks from A to B, C, D, E, F, G, H, I, K, L, and M, obſerving what *degree* the *Index* cutteth. As ſuppoſe your *Inſtrument* fixed at A, and the *Sights* directed to B, the *Index* cutteth *NE* 83 *degr.* 50 *min.* and likewiſe the *Index* directed to C, cuts 82 *degr* 5 *min.* and ſo in like manner take the reſt of the *Angles*, as you ſee them in the Table following, which muſt be noted down by you in a Paper-Book as they are taken.

The Stationary Diſtance 730 Perch, or 2 *miles* 90 Perch.

Places	*Angles*	*degr.*	*min.*
AB	*NE*	83	50
AC	*SE*	82	05
AD	*SE*	64	50
AE	*SE*	56	20
AF	*SE*	45	26
AG	*SE*	41	30
AH	*SE*	24	40
AI	*SE*	09	00
AK	*SW*	11	00
AL	*SW*	16	00
AM	*SW*	23	00

Next meaſure the *Stationary diſtance* AP, which was found 730 *Perch*, which you muſt note down likewiſe in your *Book*; then ſet your *Compaſs* and fix it at P, that the *Chard* may ſtand *North* and *South* on the *Stationary-Line* PA, then turn the *Index* to the Mark K, the *Index* cuts *NW* 24 *degrees*; Likewiſe turn the *ſights* to L, and mark the Inclination to the *Meridian*, and put it down *NW* 17 *degr.* and ſo do by all the reſt of the former *Marks* or *Points*; and note them down as you ſee in this Table PK: PL: PM: PI: PD: PB: PC: PE: PG: PF: PH: then protract theſe Obſervations, and where the *Lines* drawn from A and P Interſect each other, there muſt you deſcribe the ſeveral Places, to which you made Obſervation, where you may Write the Name of the Places.

See Figure 101

Places

Places	*Angles*	*Deg.*	*Min.*
PK	*NW*	24 :	00
PL	*NW*	17 :	00
PM	*NW*	12 :	00
PI	*NE*	9 :	00
PD	*NE*	21 :	00
PB	*NE*	33 :	50
PC	*NE*	43 :	40
PE	*NE*	54 :	10
PG	*NE*	64 :	00
PF	*NE*	73 :	20
PH	*NE*	87 :	15

Laſtly, If you would know the *Diſtance* of any of the Places thus deſcribed, one from another, you have no more to do, but open your *Compaſſes* to the two Places on the Paper; and then apply it to the ſame *Scale*, by which you laid down the *ſtationary Diſtance* A P, (which in this *Figure* was laid down by a *Scale* of 20 *Perch* to an *Inch*,) and ſo applied, it will give the diſtance ſought. See Figure 101.

You muſt remember always in taking of *Inacceſſible Heights* and *Diſtances*, that you take the two *ſtationary diſtances* as far aſunder as may be. And if at any time you require the *Altitude* of a *Church*, *Caſtle*, or *Tree*, ſtanding upon a *Hill*, you muſt perform it at two Operations; firſt by taking the *Altitude* of the *Church*, *Caſtle*, *Tree*, and *Hill* together as one *Altitude*; and ſecondly, by taking the *Altitude* of the *Hill* alone; then by *ſubtracting* the *height* of the *Hill* from the whole *height*, the *remainder* ſhall be the *height* of the *Caſtle*, or the like.

And here Note alſo, That in the taking of all manner of *Altitudes*, whether *acceſſible* or *inacceſſible*, you muſt always add the *height* of your *Inſtrument* from the *Ground* to the *height* found, the total is the true *height*. And thus much briefly touching this Matter.

The ART of Gaging of Veſſels.

CHAP. VIII.

The uſe of the Line of Numbers, and the Lines on the Gaging Rod or Staff, and the Rules in Arithmetick in Gaging of all ſorts of Veſſels, (viz.) to Gage a Cubical Veſſel, and a Cylindrical Veſſel; Alſo, Barrels, Pipes, or Hogſheads; to meaſure a Veſſel part out, to meaſure a Brewers-Tun, or a Maſh-Fat, to meaſure a Conical Veſſel, to meaſure a Riſing or Convex Crown; and alſo a Convex or Falling Crown in a Brewers Copper; alſo a Brewers Oval Tun.

PROBL. I.

How to find the Gage-Point of a Wine or Ale Gallon.

THE Gage-Point is the Diameter of a Circle whoſe ſuperficial Content is equal to the ſolid Content of the Wine or Ale Gallons; ſo the ſolid Content of a Wine Gallon, according to *Winchester* meaſure, being 231 Cube-Inches: If you conceive a Circle to contain ſo many Inches, you ſhall find the Diameter thereof to be 17:15 by this Rule. As 1 to 1.2732, ſo is 231 to 294.1092; whoſe ſquare root 17.15 *ferè* is the Gage-point for a Wine Gallon. Thus likewiſe you may diſcover the Gage Point for an *Ale-Gallon*, containing 282 Cubique Inches; for as 1 is to 1.2732, ſo is 282 to 359.0424, whoſe ſquare-root is 18.95 *ferè*, the Gage point for Ale-meaſure.

Note, you muſt be very careful in all your meaſures of all ſorts of Veſſels, their length, breadth, and *depth*, as alſo of the Head and Bong; for all ſmall Errors in them will increaſe very much in the Content.

The Deſcription of the Gaging-Rod, or Staff.

A very uſeful Gaging Rod may be thus made, in length 48 inches, upon one ſquare there is two Lines, a Line of Numbers, and a Line of 48 Inches, every Inch divided into ten parts for the ready meaſuring of any Veſſels, length, breadth, or depth.

But for the meaſuring of Great Veſſels, there is two Rods divided into Inches and ten parts, made to ſlide by each other.

On the ſecond ſide is two Lines, the firſt for the Head, and the ſecond for the Bong, which added together multiplied in the length, will give the Contents; As by Example in the ſixth Problem.

On the third ſide is two Diagonal Lines, the one for the Gage of Wine; and the other for *Ale*; which ſhews the Contents to the part $\frac{1}{10}$ of a Gallon. The Uſe in Probl. 6.

On

On the fourth side is a Line of Segments, or 63 Gallons divided in 1000 parts, as you may see in the Use by the following Table in Probl. 7. The making of this Staff is best known to the Instrument-Maker, and you may have them of Mr. *Philip Standridge* in *Bristol*, and by Mr. *Hays*, and *John Brown* in *London*, Mathematical Instrument-Makers.

The Description of Symbols used for Brevity sake.

+	*Plus* or *Addition* which is as much as to say *add.*
—	*Minus* or *Subtraction*, then you must *subtract.*
x	*In* or *Multiplication*, now you are to *multiply.*
2	To *Divide* by 2, or any other *Number* under the *Line.*
=	*Equal* to.
q	*Square* the *Numbrr* given.
C	*Cube* the *Number.*
Z	*Sum*, and Z q *Square* of the *Sum.*
√ q	To *Extract* the *square Root.*
X	*Differenee.*
X q	*Square* of the *difference.*

PROBL. II.

How to measure a Cubical Vessel.

Suppose we have a Cubical Vessel to measure, whose sides let be A B C D E F, which let be every way 24 Inches, and I desire to know how many *Gallons* of Wine or Ale the same will hold. See Figure 102. in the following Scheme.

For Beer or Ale by the Line of Numbers.

Extend the Compasses always from the Gage-Point (which for Ale is 16 $\frac{8}{10}$) unto the side of the Cube 24 *Inches*, the same extent will reach from the same 24, turning twice over unto 49 *Gallons*, and better.

For *Wine.*

Extend the Compasses always from the Gage-Point, which for Wine is 15 $\frac{2}{10}$ unto the side of the Cube 24 Inches: the same extent will reach from the same 24, turning twice over unto 59 $\frac{8}{10}$ Gallons, which is almost 60 Gallons of Wine.

The Arithmetical way.

A B, C = Gallons of Ale 49. A B, C = Gallons of Wine 59 $\frac{8}{10}$.

282 231

PROBL. III.

How to Measure a Vessel in the form of a Parallelipepidon.

Suppose we have a Vessel to measure, whose side A B let be 72 *Inches*, and breadth A C 32, and the depth C D 8 Inches. See Figure 103.

By the Line of Numbers for Ale.

You must first find a mean proportion between the length A B 72, and the breadth A C 32, by multiplying it together, and taking the Square Root thereof, or taking the middle point between 72, and 32 on the Line of Numbers, and you will find 48 for the mean.

Now Extending the Compaſſes from the Gage-point 16 $\frac{8}{10}$ to the mean Number 48 Inches, the ſame extent will reach from the depth C D 8 Inches, turning twice over unto 65 $\frac{8}{10}$ *Gallons.*

For Wine.

To find how many Wine-Gallons it is, Work by the Gage-point 15 $\frac{8}{10}$ as you did in the laſt Rule, and you will find near 79 $\frac{8}{10}$ *Gallons*; or you may find a mean proportion between the breadth A C 32, and the depth C D 8: which will be 16 Inches, and ſo work according to the former Rule.

How to work the ſame without the Gage-Point.

Example for Ale. Extend the Compaſſes from the Ale-Gallon 282 unto the length A B 72: the ſame diſtance will reach from the breadth A C 32 unto 8 $\frac{17}{100}$ Gallons: For an Inch depth, ſo for 8 Inches you may preſently find it to be 65 $\frac{136}{100}$ Gallons.

For Wine Gallons.

Take 231 for the firſt number, and by the former work you ſhall find 9 $\frac{22}{100}$ Gallons for 1 Inch depth.

The Arithmetical way.

$$\frac{AB \times : AC \times CD}{282} = = \textit{Ale-Gallons } 8\ \tfrac{17}{100}.$$

$$\frac{AB \times AC \times CD}{231} = = \textit{Wine Gallons } 9\ \tfrac{22}{100}.$$

Brewers Coolers are meaſured after the manner of this Veſſel.

Probl. IV.

How to meaſure a Cylindrical Veſſel.

See Figure 104.

Suppoſe the Diameter of the Head A B be 24 Inches, and the length thereof A C be 30 Inches, To find the contents in Ale-Gallons. Extend the Compaſſes always from the Gage-point, which for Ale is 18 $\frac{24}{100}$ Inches unto the Diameter 24 Inches; the ſame diſtance will reach from the length 30 Inches turned twice over unto 48 $\frac{8}{10}$ *Gallons.*

For Wine.

Extend the Compaſſes from the Gage-point 17 $\frac{11}{100}$ unto the Diameter 24; the ſame diſtance will reach from 30 turned twice to 58 $\frac{7}{10}$ Gallons.

The Arithmetical way.

For Ale. $\frac{AB\,q \times AC}{359} = = \textit{Ale-Gallons (viz.) } 48\ \tfrac{11}{100}.$

For Wine. $\frac{AB\,q \times AC}{294} = = \textit{Wine Gallons, (viz.) } 58\ \tfrac{22}{100}.$

Probl. V.

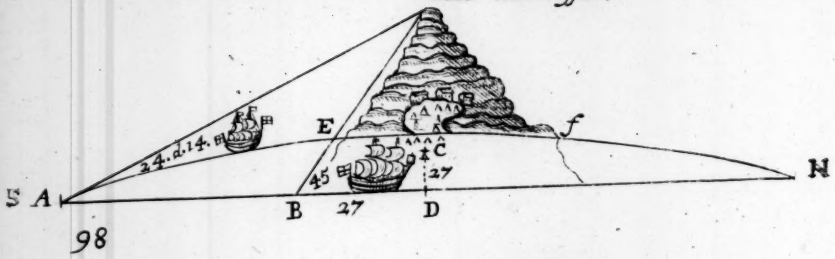
How to meaſure a Globical Veſſel.

See Figure 105.

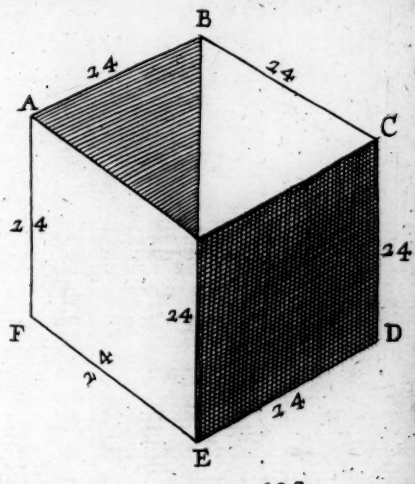
Suppoſe the Diameter of the Globe be A B 24 Inches: Then to know the Contents in Ale or Wine, it is thus.

For

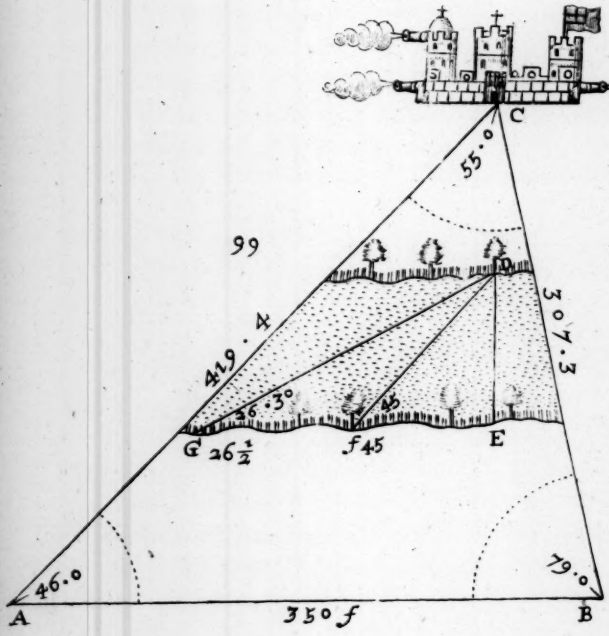
Pico Tenariffe.

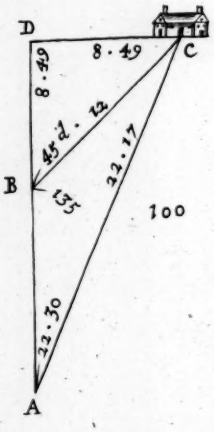


98

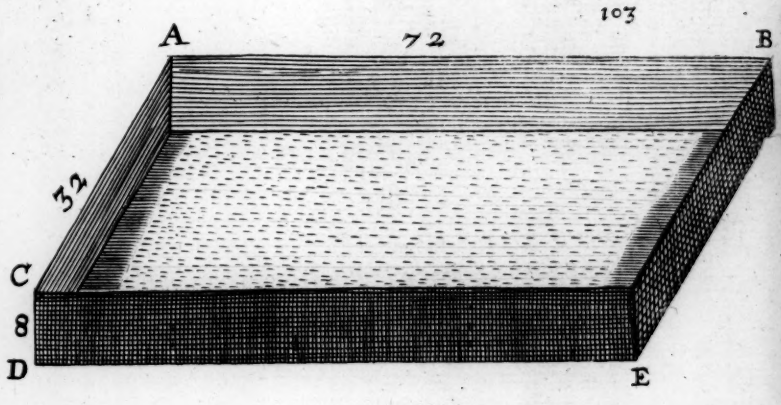


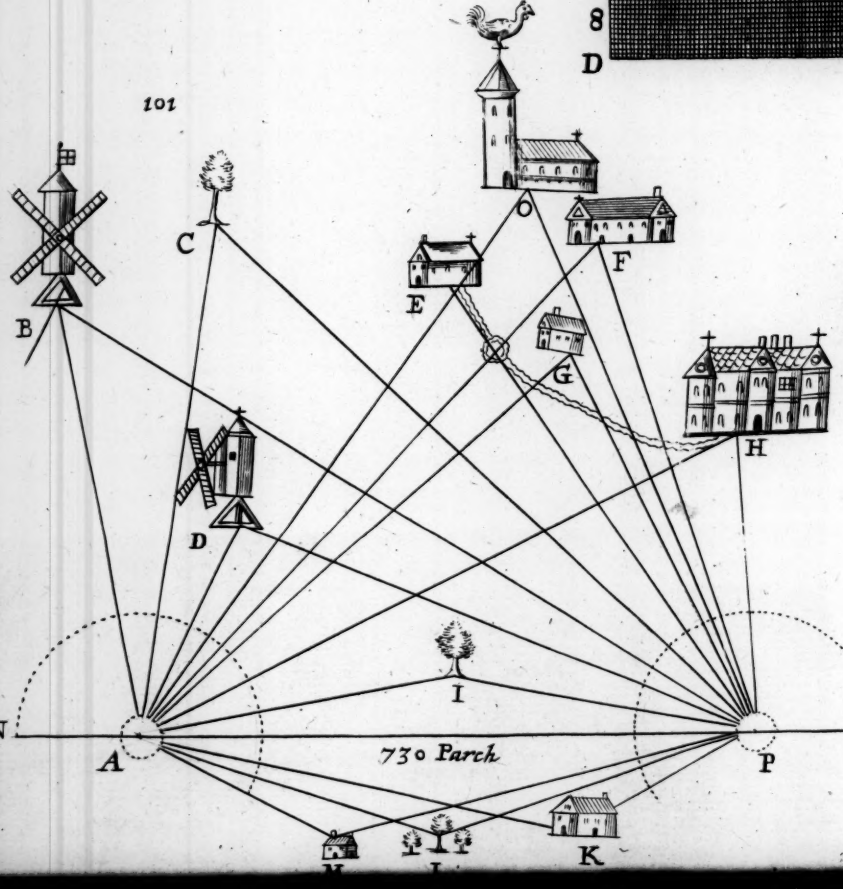
102



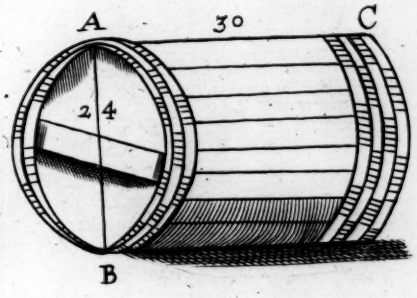


103

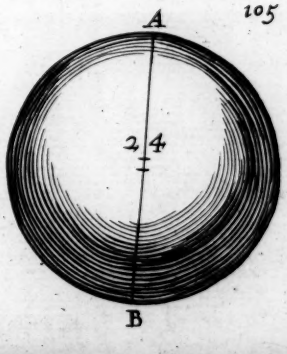


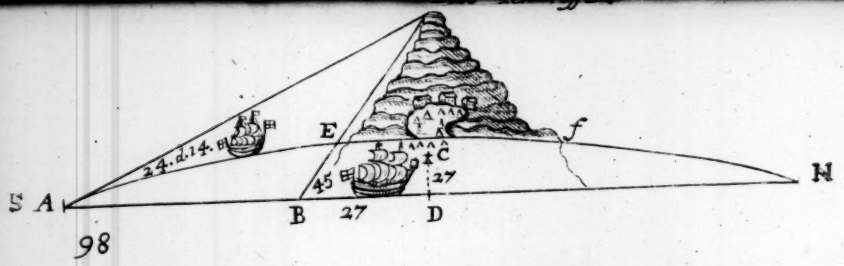


104

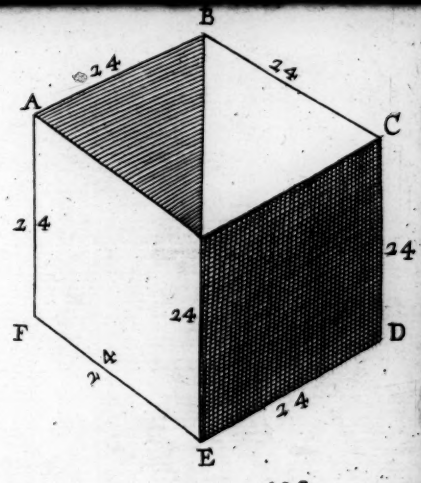


105

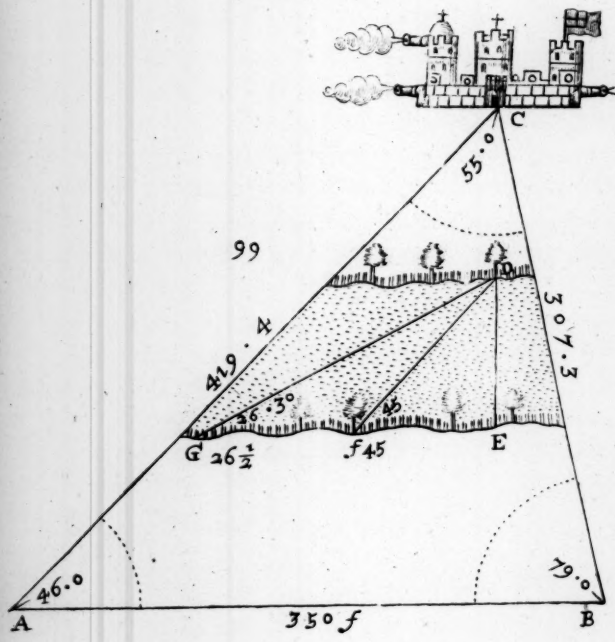


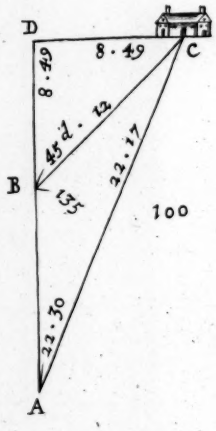


98



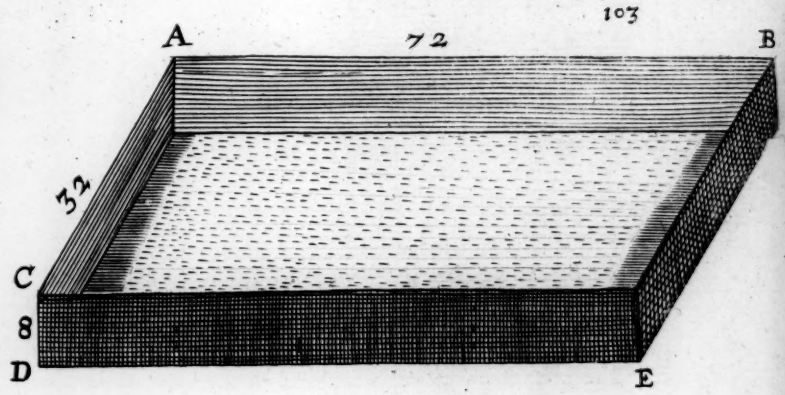
102



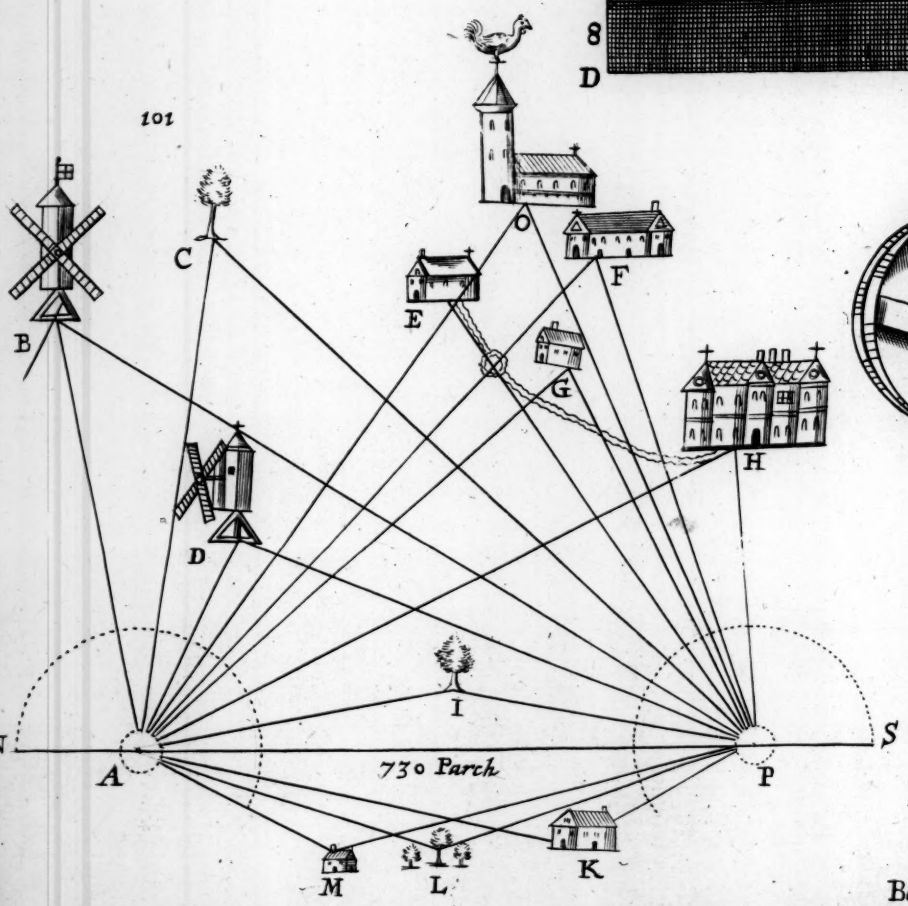


100

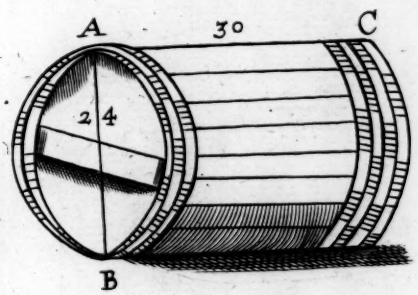
103



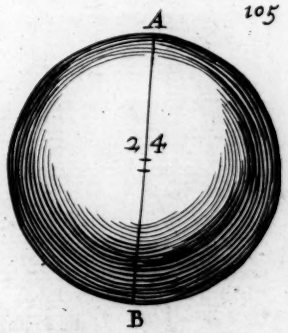
101



104



105



Book V: p. 26: 27.

For Ale.

Extend the Compaſſes from the Gage-point, which is 23 $\frac{21}{100}$ unto the Diameter A B 24 Inches; the ſame diſtance will reach from the ſame 24 turned twice over unto 25 $\frac{2}{3}$ Gallons of Ale.

For Wine.

Extend the Compaſſes from the Gage-point 21 unto the Diameter 24 turned twice over, as before, you ſhall have 31 $\frac{1}{3}$ Gallons.

The Arithmetical way.

For Ale. A B . C
538
——— ——— ==*Gallons*, (*viz.*) 25 $\frac{49}{100}$.

For Wine. A B . C
441
——— ——— ==*Gallons*, (*viz.*) 31 $\frac{33}{100}$.

23
20
3
7
21
x(1(2 $\frac{1}{10}$
x 0
20
2 $\frac{1}{10}$
22 $\frac{1}{10}$

PROBL. VI.

How to meaſure a Barrel, Pipe, Butt, Puncheon, Hogſhead, or ſmall Cask.

Suppoſe you have a Cask to meaſure, whoſe length is A B 27 Inches, and depth at the Bong C D 23 Inches, and breadth at the Head E F 20 Inches.

You are to find a mean-Diameter between the Head and the Bong by this Rule.

Take the difference between 23 and 20, which is 3; which being multiplied by 7, the Product is 21, and divided by 10, the Quotient will be 2 $\frac{1}{10}$ which added to the leſſer Diameter 20, you have 22 $\frac{1}{10}$ for the mean-Diameter.

Then for Ale.

Extend the Compaſſes from the Gage-point 18 $\frac{21}{100}$ unto the Mean-diameter 22 $\frac{1}{10}$, the ſame will reach from the length 27 Inches turned twice over, to 36 $\frac{7}{10}$ Gallons.

For Wine.

Extend the Compaſſes from the Gage-point 15 $\frac{11}{100}$ unto 22 $\frac{1}{10}$, the ſame will reach from 27 to 44 $\frac{3}{10}$ *Gallons.*

The Arithmetical way.

For Ale. 2 C D *q* x E F *q* : x A B
1077
——— ——— ——— ==*Gallons* (*viz.*) 36 $\frac{56}{100}$.

For Wine. 2 C D *q* x E F *q* : x A B
882
——— ——— ——— ==*Gallons* 44 $\frac{63}{100}$.

M ſtands for Mean, D for Diameter, MD for mean-Diameter.

There is another way to work this Veſſel Arithmetically by the Mean-diameter which was before found to be 22 $\frac{1}{10}$ Inches. See Figure 106.

Thus.

For Ale M D *q* x A B
359
——— ——— ——— ==*Gallons*, (*viz.*) 36 $\frac{71}{100}$.

For Wine. M D *q* x A B
294
——— ——— ——— ==*Gallons*, (*viz.*) 44 $\frac{85}{100}$.

By the Diagonal Line on the Rod and Staff.

Take the meaſure with your Rod from the Bong-hole at C to the lower part of the Head at F, as the Line F C, which in this Example is near 25 $\frac{4}{10}$ Inches: So if you would know how much Ale the Cask will hold, you ſhall find the Bong hole to cut in the Diagonal Line 36 $\frac{1}{10}$ Gallons. And for Wine it will cut 44 $\frac{1}{4}$ *Gallons* the Contents required.

The Wine gallons being given, to know what it ſhall hold in Ale.

The

The Use of the two Lines upon the Rod marked Head and Bong; and of this Table for Wine-measure.

Extend the Compasses from 231 to 282, the same extent will reach from the Content in Wine-Gallons $44\frac{8}{10}$ to $36\frac{7}{10}$ the Contents in Ale Gallons.

A Table for the Gaging of Vessels.

The Diameter in Inches.	Head. G	Head. pts.	Bong. G	Bong. pts.		Head. G	Head. pts.	Bong. G	Bong. pts.
D									
01	0	001	0	002	31	1	089	2	178
02	0	004	0	009	32	1	100	2	321
03	0	010	0	020	33	1	234	2	468
04	0	018	0	036	34	1	310	2	620
05	0	028	0	056	35	1	388	2	776
06	0	041	0	081	36	1	469	2	938
07	0	056	0	111	37	1	551	3	102
08	0	072	0	145	38	1	636	3	272
09	0	092	0	184	39	1	724	3	448
100	0	113	0	226	40	1	813	3	626
110	0	137	0	274	41	1	904	3	809
12	0	163	0	326	42	2	000	4	000
13	0	192	0	383	43	2	096	4	192
14	0	222	0	444	44	2	194	4	388
15	0	255	0	510	45	2	295	4	591
16	0	290	0	580	46	2	398	4	796
17	0	328	0	517	47	2	503	5	007
18	0	367	0	734	48	2	611	5	222
19	0	409	0	818	49	2	721	5	442
20	0	453	0	906	50	2	833	5	666
21	0	500	1	000	51	2	948	5	896
22	0	548	1	097	52	3	064	6	129
23	0	599	1	199	53	3	183	6	367
24	0	653	1	306	54	3	305	6	610
25	0	708	1	416	55	3	428	6	856
26	0	766	1	532	56	3	554	7	108
27	0	826	1	652	57	3	682	7	364
28	0	888	1	777	58	3	812	7	625
29	0	953	1	906	59	3	945	7	890
30	1	020	2	040	60	4	080	8	160

And as 231 to 282, so are the Ale Gallons to the Wine Gallons.

The Use of this Table is the same with the Rod, only in the Table you have the perfect Number, but upon the Staff, for 10 account 100, for every small Division is 10; and you must estimate the parts of these small Divisions, and then is the Work all one as with this Table, (*viz.*)

You must measure the Diameter first at the Head, and find the Number in the Table, or Rod belonging to it; then measure the Diameter at the Bong, and likewise in the Table, or on the Rod, find the Number belonging to that; then add those two together, and multiply the Sum thereof by the Inches of the Vessels length, from Head to Head on the inside.

The Table and Staff shews for 20 Inches at the Head —— 0,453
For 23 Inches at the Bong —— 1,199

These two added together, make —— 1,652
27

Which being multiplied by 27, the length, —— 11564
—— 3304

Makes —— 44604

According to this Operation, it should be 44 *Gallons* $\frac{624}{1000}$ *parts*, which difference is of no Moment in these Conclusions.

PROBL.

PROBL. VII.

By the Line of Segments on the Rod or Staff, to find the Quantity of Liquor in a Cask that is part full.

SUppose you would know the Quantity of Liquor in a Cask whose depth at the Bong is 23 Inches, and let the Liquor be in height 16 Inches, and the whole Cask to hold 44 $\frac{21}{100}$ *Gallons*. See Figure 107.

By the Line of Numbers on the Staff, the proportion will be, as the whole depth 23 Inches is to the depth in Liquor 16 Inches, so is 1000 to 695 parts.

Which being sought for in the Segment-line on the Staff, you shall have in the Line by it 741.

Now if you extend the Compasses from 1000 to 741, the same distance will reach from 44 $\frac{21}{100}$, the Content of the whole Cask to 33 $\frac{5}{10}$, that is, 33 $\frac{2}{10}$ Gallons of Wine in the Cask.

PROBL. VIII.

How to measure a Brewers Tun, or a Mash-Fat.

LEt the Tun be A C D E, whose Diameter in the bottom let be E D 98 Inches, and the Diameter at the top A C let be 90 Inches, add both the Diameters together, you have 188 Inches; then take the half thereof, and it is 94 Inches, this is the Mean diameter F G; then get the height of the Tun, which let be A B 40 Inches. Now to know how many Barrels of Beer it will hold according to 36 Gallons to the Barrel, work thus. See Figure 108.

By the Line of Numbers.

Extend the Compasses always from 113 $\frac{7}{10}$, (which is the Gage-point for a Barrel) unto the Mean-diameter 94, the same distance will reach from the height 40 Inches turned twice over unto 27 $\frac{1}{3}$ of a Barrel.

The Arithmetical way by the Mean-diameter.

$$\frac{FG\,q \times AB}{359} = \textit{Gallons}\ 984\ \tfrac{1}{10}.$$

Which being divided by 36, you have 27 Barrels 12 $\frac{1}{2}$ *Gallons*.

Or thus for Barrels.

$$\frac{FG\,q \times AB}{12924} = \textit{Barrels}\ 27\ \tfrac{351}{1000}.$$

This Arithmetical way by the Mean-diameter is not absolutely true, yet near enough for Brewers Tuns, by reason the difference of Diameters between the bottom and the top, is seldom above 7 or 8 Inches: But to do it exactly take this way of working this Tun.

The Arithmetical way.

$$\frac{ED\,q + AC\,q; + ED \times AC, \times AB}{1077} = 985\ \textit{Gallons}\ \tfrac{1}{10}.$$

Divide

Divide 985 $\frac{1}{10}$ Gallons by 36, and the Quotient is 27 Barrels, and 13 Gallons: So the Tun will hold 27 Barrels 13 Gallons $\frac{1}{10}$.

Or thus for Barrels.

$$\frac{ED\,q + AC\,q, + ED \times AC, \times AB}{38772} = 27 \text{ Barrels } \frac{37}{100}.$$

Probl. IX.

How to measure a Conical Vessel, having the Height and the Diameter at the Base.

Suppose the Diameter at the Base AB be 98 Inches, and the height DC 490 Inches.

Then by the Line of Numbers for Barrels of Ale or Beer.

See Figure 109.

Extend the Compasses from the Gage-point 109 $\frac{2}{10}$ unto the Diameter AB 98, the same will reach from the height of the Cone DC 490, turned twice over unto 121 $\frac{4}{10}$ Barrels *ferè*.

This is the Proportion to work for great Cones to have it in Barrels, but small Cones have it in Gallons.

Work thus,

Extend the Compasses from the Gage-point 32 $\frac{8}{10}$ unto the Diameter of the Base 98, the same will reach from the height of the Cone 490, twice turned unto 4369 $\frac{5}{10}$ Gallons.

The Arithmetical way.

For Gallons.

$$\frac{AB\,q \times DC}{1077} = 4369\ \tfrac{5}{10}\ \textit{Gallons}.$$

Which being divided by 36, you have 121 *Barrels* 13 *Gallons*.

Or thus for *Barrels*.

$$\frac{AB\,q, \times DC}{38772} = 121\ \tfrac{37}{100}\ \textit{Barrels}.$$

The Brewers Tun before measured may be measured after this manner following.

To find the height of the greater Cone, say, as the difference of the Diameters 8 Inches is to the height of the Tun 40 Inches: So is the Diameter of the bottom AB 98 Inches to the greater height DC 490 Inches, from whence subtract 40, there remains the height of the lesser Cone GC 450 Inches.

Now working as before for the Content of each Cone.

The greater Cone will be found to be —— 4369 *Gallons* —— 5 *Parts*
And the lesser Cone to contain —— —— 3384 *Gallons* —— 4 *Parts*.
Which subtracted from the greater Cone, there remains 985 *Gallons* $\frac{1}{10}$ *Parts*, which is 27 *Barrels* 13 *Gallons* $\frac{1}{10}$.

Probl.

PROBL. X.

How to meaſure a Segment of a Globe or Sphere, which ſerves for the riſing, or falling Crown in a Brewers Copper.

ADmit you have the Diameter of the Crown A B 80 Inches, and the height thereof C D 6 Inches.

$$\frac{AB^{q} + 1\frac{1}{3}CD^{q} \times CD}{718.} = 53\ \tfrac{8}{10}\ \textit{Gallons.}$$

PROBL. XI.

How to reduce Ale Gallons into Wine Gallons.

Example.

THere is a Veſſel that holds 60 Gallons of Ale; the Queſtion is how many Gallons of Wine it will hold.

The Proportion.

As 231 is to 282 : ſo 60 Ale to } 73 $\frac{29}{77}$ *Wine Gallons.*
Or as 77 is to 94 : ſo is 60 Ale to }

The reaſon is this, 231 Ale-Gallons is 282 Wine-Gallons, or 77 Ale Gallons is 94 Wine-Gallons.

Extend the Compaſſes from the Wine-Gallon 231 to the Ale-Gallon 282, the ſame diſtance will reach from 60 to 73 $\frac{3}{10}$ Gallons.

PROBL. XII.

How to meaſure a Brewers Oval Tun, whoſe baſes are Ellipſes of different magnitudes, having their Axes parallel to each other.

SUppoſe the extreme Diameters at the bottom to be A B 120 inches, and E F 90 inches, and thoſe at the top to be C D 112 inches, and G H 84 inches, and the depth of the Tun C b 40 inches; to find the Content in Gallons.

The Rule.

$$\frac{AB + \frac{1}{2}CD : \times EF + : CD + \frac{1}{2}AB : \times GH \times Cb}{1077} = 1124.9\ \textit{Gallons.}$$

That is, to the greater Diameter at the bottom add half the greater Diameter at the top, and multiply that ſum by the leſſer Diameter at the bottom, reſerving the Product; then to the greater Diameter at the top add half the greater Diameter at the bottom, and multiply the Sum by the leſſer Diameter at the top, and reſerve the Product, add theſe two Products together, and multiply that Sum by the depth, and divide by 1077, the Quotient is the Content in Gallons; which will be found to be 1124.9 Gallons.

CHAP. IX.

Wherein is ſhewed both Arithmetically and Inſtrumentally how to meaſure all kind of plain Superficies, as Walls, Timber-work, Roofs of Houſes, Tyling, Board, Glaſs, Wainſcot, Pavement, and the like; as alſo Timber and Stone.

PROBL. I.

FOraſmuch as it is very requiſite for a compleat Artiſt to know how to meaſure all manner of Buildings, as Walls, Timber-work, Tyling, and ſuch like; I ſhall in the following Example make Illuſtration thereof.

Note this, that Walls are meaſured by the Rod of 16½ Feet, Wainſcot by the Yard, and Board and Glaſs by the Foot. Therefore meaſuring any of theſe things, conſideration muſt be had to the juſt Form and Figure thereof: Then by the following Rules you may have the Content thereof.

As for Example.

Suppoſe there be a Wall in the form of this Figure being an oblong, and it is required to know how many Perch, or Rods are contained therein.

The Arithmetical way for Perch.

$$\frac{AB \times AD,}{272\frac{1}{4}.} = 4 \text{ Rod } \frac{1}{2} \text{ 29 feet.}$$

Extend the Compaſſes always from 272¼ to the length 66, the ſame extent will reach from the height 19 foot unto the true Contents of the Wall 4 Rood ½, and 29 feet.



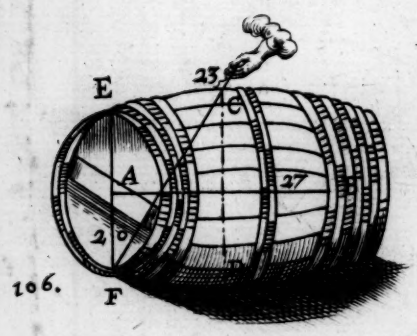
Note, that in meaſuring Brick-work, if the Wall be 1 Brick ½ thick, then the Content before found is the meaſure of that Wall, but if the thickneſs be more or leſs, there muſt be an allowance made accordingly; that is, for every ½ Brick above 1 Brick ½ you muſt add ⅓ of the former meaſure to the Content before found; for every ½ Brick leſs than 1 Brick ½ you muſt ſubtract ⅓ from that meaſure.



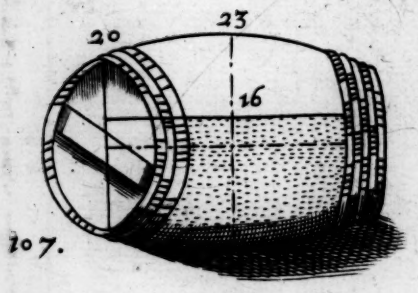
But ſuppoſe A B C be a Gable end, which is in the form of a Triangle, therefore multiply 16 the Perpendicular by half the baſe A C 10, the Product is 190, the Content in Feet.

But in meaſuring of Chimneys, which require more Workmanſhip than other ordinary Walls, they are uſually accounted as double meaſure, that is, firſt meaſure them as ſingle meaſure, and the double of that meaſure produceth the Content.

Note



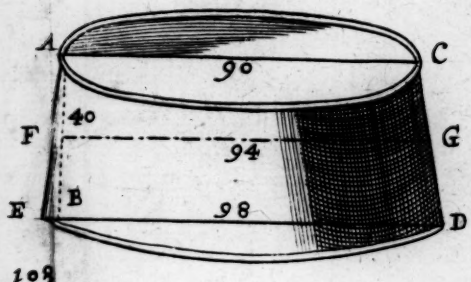
106.



107.



The Tun.

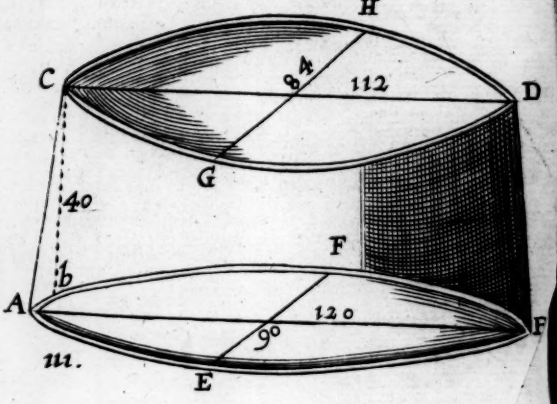


108.

A Brewers Ovall Tun.

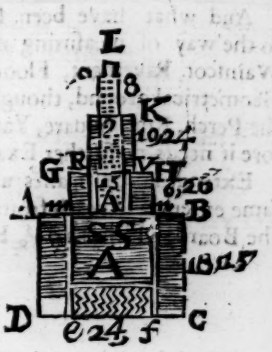


110.



111.

Note that if the Chimney ſtand by it ſelf, the Back is to be meaſured with the reſt of the Chimney; but the Back ſtanding againſt a Wall, the Wall muſt not be meaſured with the Chimney.



Admit this Figure L I K, G H, A B, D C be a Chimney to be meaſured, and according to double meaſure, the Content is required.

Firſt meaſure the Braſt-Wall E F, and the Jaumes D E and F C, which together makes 24 Feet; next take the height of the Square C B 18. 15 Feet, which multiplied together, the Product is 435: 60 Feet for the Content of the Figure A B D C. Then for the Square G H m n, the Braſt-Wall G H, and the Jaumes is 15 Feet, the height n H 6: 26 Feet, multiplied as before, makes 93: 90 Feet, for the Content of the Square G H m n.

By the like manner of Working, you will have the Contents of the Square I K R V: 92: 16; likewiſe the Chimney-Shaft in compaſs is 9 Feet, and 8 Foot high, multiplied together as before, is 72 Feet for the Contents: Add theſe four Sums together, the Total is 693: 66 Feet, doubled is 1387 Feet $\frac{32}{100}$ Feet the Content of the Chimney according to Cuſtomary meaſure.

		Feet. Parts.
The Squares	A B D C:	438: 66
	G H m n:	93: 90
	I K R V:	92: 16
The Shaft	I L:	72: 00
	The Sum	693: 66
	doubled.	693: 66
	The Total Sum.	1387: 32

Which reduced into Perches as before, is 5 Rod 26 Foot.

Note that Slate-work and Tyling, alſo Roofs of Houſes, Timber-work, Partitions and Floors, are meaſured by the Square of 100 Foot.

PROBL. II.

How to meaſure Boards, Glaſs, Pavement, Wainſcot, and the like.

IN the laſt Problem we have ſaid that Boards, Glaſs, Pavement, and Wainſcot, and the like, they are commonly accounted by the Foot or Yard; Therefore to make this plain, we ſhall inſtance only upon Boards which are commonly cut out in long Squares.

How to meaſure them.

Take the length and breadth in Inches and Parts, multiply one by the other, the Product will ſhew the Content in Inches; that divided by 144 (the Number of Inches in one Foot) the Quotient will tell you the Number of Feet, and the remainder are inches.

For Example.

Admit I have a Board that is 7 Foot long, and 18 inches broad; multiply 84 Inches (which is in 7 Feet) by 18 inches, the Product is 1512; which divide by 144 the number of Inches in a Foot of flat-meaſure, and the Quotient ſhews 10 feet, and 72 remains, (which is $\frac{1}{2}$ of 144) therefore the Board contains 10 foot $\frac{1}{2}$; but many times the Board falls out to be broader at one end than it is at the other, then add together the breadth at each end; then take the $\frac{1}{2}$ for the true breadth, and work as before.

Such Rules are made by *Walter Hays* in *Moreſields*, and in *Briſtol* by *P. Staynard*.

And what have been ſaid of Board-meaſure, the ſame is to be underſtood in the way of meaſuring not only Boards and Glaſs, but likewiſe all manner of Wainſcot, Pavement, Floors, and ſuch like; they depend upon one and the ſame Geometrical ground, though they be reckoned by different meaſures, as you ſee by the Perch, Rod, Square, Yard, or Foot, according to the Cuſtom of the Place, therefore it needs no further Example.

Extend the Compaſſes always from 12 Inches unto the breadth 18 Inches, the ſame extent will reach from the length 7 foot, unto the number of Square foot in the Board, which is 10 $\frac{5}{10}$ Foot.

PROBL. III.

The Menſuration of Solid Bodies of Timber and Stone, and firſt of Squared-Timber.

WHatſoever hath length, breadth, and thickneſs, is called a Solid-body; as Timber and Stone, and the like, which are uſually meaſured by the Foot: And therefore you are to obſerve that a foot of Timber or Stone is a Foot every way in the form of a Die.

Suppoſe a piece of Timber being at each end 16 Inches one way, and 25 Inches the other, and 14 foot long, to find the Content.

By the Line of Numbers.

Take the middle between 16 and 25, which you will find to be 20, then to find the Content.

Extend the Compaſſes (always) from 12 Inches unto the Mean Square 20 Inches; the ſame will reach from the length 14 Foot turned twice over to 38 $\frac{2}{10}$ foot of Timber.

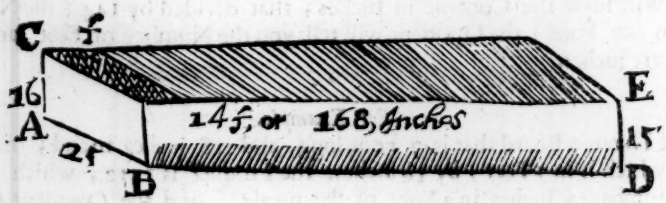
The Arithmetical way.

Thus, $\frac{AB \times AC, \times BD}{144} =$ to the Contents in feet $38\ \frac{128}{144}$.

Or thus, $\frac{AB \times AC \times BD}{1728.} =$ (reduced into inches) $38\ \frac{1536}{1728}$ feet.

A common Error amongſt moſt Carpenters.

Yet it is common with the Carpenters to add the breadth and thickneſs together, and to take the half thereof for the mean Square, but that way is very erroneous, eſpecially when the difference between the ſide is much.



In the former Example one ſide is 25, the other 16, the Sum 41, the half 20 $\frac{1}{10}$ Inches; that is, half an inch too much, for the Mean Square is but 20, ſo that by taking 20 $\frac{1}{2}$, it makes the piece of Timber 40 foot $\frac{2}{10}$, when it is but 38 $\frac{2}{10}$ feet, which is two foot too much.

Now

Now if a piece of Timber be tapering, the common way is to take the Square in the middle; and ſo to work as in the laſt example, but it is erroneous.

Example.

Admit a Piece of Timber were 25 inches Square at one end, and 15 Inches at the other, and fourteen foot long.

This is the true way by Arithmetick.

$$\frac{AB\,q + DE\,q + Æ.\ x\,BD}{432} = \text{Contents } 39\tfrac{2}{10} \qquad Æ \text{ is} = AB \times DE$$

PROBL. IV.

How to find how many Inches in length will make one Foot of Timber, in a piece that is equally ſquared at each end.

SUppoſe you have a piece of Timber that is ſquare 16 inches every way, and you would know how many Inches in length will make one foot of Timber.

By the Line of Numbers.

Extend the Compaſſes always from 16 inches the ſide of the Square to 12 inches, the ſame turned twice over from 12 inches will reach to $6\frac{1}{4}$ inches, the length for one foot of Timber.

The Arithmetical way.

$$\frac{1728}{AC\,16\,q} = 6\tfrac{128}{500} \text{ or } 6\tfrac{1}{4} \textit{ Inches.}$$

PROBL. V.

How to meaſure round Timber.

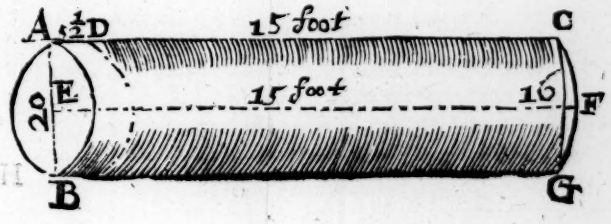
ADmit you were to meaſure a piece of round Timber, whoſe Diameter or thickneſs at either end is 20 inches, I deſire to know how many inches in length will make one foot of Timber.

By the Line of Numbers.

Extend the Compaſſes from the Diameter A B 20 inches unto the conſtant Number 13, the ſame diſtance will reach from 12 turned twice over unto $5\frac{1}{2}$ inches for $1\frac{1}{10}$ foot, as A D.

The Arithmetical way.

$$\frac{2187}{AB\,q} = AD\ 5\tfrac{46}{100} \text{ inches, for one foot.}$$



Having

Having the Diameter of a piece of Timber, as admit it to be 20 inches, and the length ſuppoſe 15 foot; to find the Contents in feet.

By the Line of Numbers.

Extend the Compaſſes always from 13 $\frac{5}{10}$ to the Diameter A B 20 inches, the ſame diſtance will reach from 15 the length turned twice over unto the Contents 32 $\frac{2}{10}$ feet in the piece.

The Arithmetical way.

Square the Diameter A B 20, and it is 400; treble it by 4, and it is 1600, multiply it by the length 15, and the Product is 24000, that divide by 729 and the Content is 32 $\frac{2}{10}$ feet.

Here is likewiſe another brief Rule Arithmetically thus.

Square the Diameter A B 20, and it will be 400; multiply that by 11, and it is 4400, divide it by 14, and the Quotient is 314, and 4 remains, which multiplied by the length 15, the Product is 4714; that divide by 144, and the Quotient is 32 $\frac{7}{10}$.

Now the common way uſed by Artificers, is to meaſure round a piece of Timber or Tree, and to take the one fourth part for the Square, which is very erroneous and falſe.

For Example.

The meaſure of the Circumference of the Piece before-going is 62 $\frac{8}{10}$ inches, the $\frac{1}{4}$ thereof is 15 $\frac{7}{10}$ inches, which they take to be the Square; which multiplied into it ſelf, produceth 246 $\frac{5}{10}$ for the *Area* of the Baſe; which multiplied by the length 15 foot, the Product is 3697 $\frac{5}{10}$ the Contents in feet and parts; that divided by 144, the Quotient is 25 $\frac{7}{10}$, that is differing from the Truth no leſs than 7 foot, which the Buyer hath more than his due; but I conceive they agree in the Price to ſtand to that meaſure, by reaſon of the waſt in Chips before it is brought into Squares; but the beſt way will be to meaſure the Tree right, and afterwards allow for the Waſt; or elſe in time Error will be taken for Truth, and Truth will be accounted Error, as it is by too many this day.

How to meaſure a round piece of Tapering Timber.

Admit the Diameter of a great End of a piece of Tapering Timber be A B 20 Inches, and the leſſer end C D 16 Inches, and the length E F 15 foot. To find the Content the common way is this, add both the Diameters 20 and 16, the Sum is 36, the half is 18 for the Mean.

Then extend the Compaſſes always from 13 $\frac{5}{10}$ to the Mean-diameter 18, the ſame will reach from the length 15 foot turned twice over unto 26 $\frac{5}{10}$ foot.

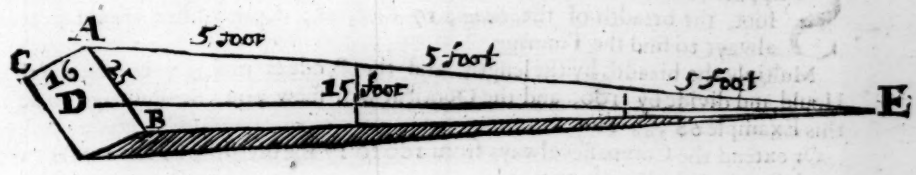
The true way by Arithmetick.

$$\frac{AB\,q + CG\,q + AB \times CG : \times EF}{550} = \text{Content in Feet, } 26\ \tfrac{6}{10}.$$

PROBL. VI.

How to measure a Pyramidal piece of Timber.

ADmit you have a piece of Timber to measure, whose thickness at the Base is 25 inches A B, and breadth A C 16 inches: And the length of the piece D E 15 foot.



By the Line of Numbers.

First, by the line of Numbers find a Mean-proportion between 25 and 16 by dividing it into two parts, and the middle will fall upon 20 inches, the Mean-proportional required.

Then extend the Compasses always from 20 $\frac{8}{10}$ unto the Mean-proportional 20 Inches, the same distance will reach from the length 15 foot turned twice over unto 13 $\frac{8}{10}$ foot of Timber.

The Arithmetical way.

$$\frac{AB \times AC \times DE}{432} = 13 \text{ foot } \tfrac{88}{100} \text{ parts of Timber in the Piece.}$$

Or

$$\frac{AB \times AC \times \frac{1}{3} DE}{144} = 13 \text{ foot } \tfrac{88}{100} \text{ parts, that is 13 foot and above three quarters.}$$

PROBL. VII.

How to measure a Conical piece of Timber.

ADmit you had a Cone Piece of Timber whose Base or Diameter at the End A B is 28 inches, and the length thereof C D 15 foot, it is required to know how many foot of Timber is in the piece.



Extend the Compasses always from 23 $\frac{4}{10}$ unto the Diameter A B 28, the same distance will reach from the length 15 foot turned twice over unto 21 $\frac{4}{10}$.

The Arithmetical way.

$$\frac{AB^q \times CD}{550} = 21 \tfrac{88}{100} \text{ foot of Timber in the Cone Piece.}$$

CHAP.

CHAP. X.

For the Burden of a Ship, or her Tunnage, take these Rules following.

SECT. I.

SUppose you were to find the burthen of a Ship that the length of her Keel is 45 foot, the breadth of the *Beam*, 17 foot, the depth of her Hould 9 foot, always to find the Tunnage.

Multiply the breadth by the length, and the Product multiply by the depth in Hould, and divide by 100, and the Quotient will shew you the Tunnage to be in this Example 68 $\frac{85}{100}$ Tun.

Or extend the Compasses always from 100 to 17 the breadth, the same extent will reach from 45 the length, to 7 $\frac{65}{100}$.

Then extend the Compasses from 1 unto 7 $\frac{65}{100}$, and the same distance will reach from the depth in Hould 9 foot to the Tunnage 68 $\frac{8}{10}$ Tun of King's Tunnage.

But for Merchants Ships, who give no allowance for Ordnance, Masts, Sails, Cables, and Anchors, which is all a Burden, and no Tunnage.

You must work thus for the Tunnage.

SECT. II.

$$\frac{45 \times 17 \times 9}{95} = 72\ \tfrac{85}{100}\ \text{Tun Burden.}$$

Or, extend from 95 always to the length of the Keel 45, the same will reach from the breadth 17 of the Beam to a 4 Number, (as to 8 $\frac{05}{100}$) then extend from 1 to 8 $\frac{25}{100}$ the same distance will reach from the depth in Hould 9 foot to the Burden 72 $\frac{8}{10}$ Tun.

SECT. III.

Having the Proportion of any one Ship in Burden, with the length of her Keel, to build another of any Burden according to that proportion.

ADmit I have a Ship of 80 Tun, the length of her Keel is 46 foot. Now I am to build a Ship whose *Keel* must be 65 foot of the same mould; I desire to know how many Tun she must be.

Extend the Compasses from 46 foot unto 65 *foot*, the same extent will reach from the Burden 80 Tun, being turned 3 times over unto 225 $\frac{7}{10}$ Tuns.

Note that C signifies the Cube of the Number preceding.

The Arithmetical way.

$$\frac{80 \times 65\,C}{46\,C} = 225\ \tfrac{7}{10}\ \text{Tuns.}$$

SECT.

SECT. IV.

ADmit you had a Ship of 226 Tuns, and the length of her Keel is 65 foot; Now I would build a Ship of twice the Burden, that is 452 Tuns; Now I would desire to know the length of her Keel.

Extend the Compasse from 226 unto 452, the $\frac{1}{2}$ of that distance will reach from the length of her Keel 65 foot unto the length of the greater Ships Keel 81 $\frac{5}{10}$ foot *ferè*.

The Arithmetical way.

$$\sqrt{C}: \frac{65.\ C. \times 452.}{226} = 81\ \tfrac{5}{10}\ \text{foot.}$$

Note, $\sqrt{C}$ signifies the Cube Root of the quantity following it.

CHAP. XI.

Containing the Principles of the Art of Gunnery, in a Compendious form, with divers Conclusions both Arithmetical, Geometrical, Instrumental, and by Tables.

SECT. I.

The Qualifications every Gunner ought to have, and the Properties, Duty, and Office of a Gunner.

HE ought to have skill in *Arithmetick*, to work any Proportion by the Rule of Three, to extract the Square and Cube Roots, and to be perfect in the Art of Decimal Arithmetick, and to be skilful in Geometry; that he may be able to measure heights, depths, breadths, and lengths; and to draw the Plot of any piece of ground. A Gunner that hath a Charge ought also to have in readiness all necessary things for his Artillery:

As Wheels, Axle-trees, Ladles, Rammers, Sheep-skins to make Spunges, Gunpowder, Shot, Tampions, Chain-shot, Cross-bar-shot, Canvas, or Strong Paper to make Cartrages, Fire-works, Artificial Torches, Dark Lanthorns; again, (to Mount and Dismount Guns,) Hand-spikes, Coyns, Budge-Bartels to carry Powder, and Baskets to carry Shot to your Piece. When leisure will permit, he is to choose good Match, to arm his Linstocks in readiness for to give fire, and also a pair of Caleper Compasses to measure the Diameters of Shot, or the Muzzle, or Base-ring of a Piece, or the like; and also a small Brass pair of Scales and Weights, a Ruler divided into Inches, and 8 or 10 Parts in every Inch, for the ready measuring of Cartrages, and how to fill them.

A Gunner ought to know the Names, Length, Weight and Fortification of every Piece about the Chamber (that is as far as the Piece is laden with Powder;) and be able to tell readily how much Powder is a due Charge for any Piece, what Shot is fit, how many Matrosses must attend the same, how many Horses or Oxen will draw the said Piece, or Men, if occasion be. He must be careful in making choice of a sober honest man for the Yeoman of the Powder; and he must not beat up the Head of his Powder-Barrels with an Iron Tool, but with a Wooden Mallet, which can never fire the same: A Gunner ought to try his Piece, to know whether it be true bored or not, to proportion his Charge according to the thinnest side of the Metal, and accordingly take his direction at the Britch of the Piece, just over that place where by Art he finds the middle of the Bore within the Piece is; by which means a good Shot may be made out of a bad Piece.

Before he makes a Shot, he is to conſider, that if the Piece lie point blank, or under Metal, he ought to put in a ſufficient Wadd after the Shot, to keep it cloſe to the Powder; for it ſhould not be cloſe, the Piece will break in the vacant place; but in caſe you mount your Piece, put no Wadd after the Shot.

And one chief thing is to know very well how to diſport his Piece, be it either true bored, or not true bored, which he may try firſt.

When a fit man is entertained, the Maſter *Gunner* (whom he ſerves) ſhould bring him to his Pieces, and give him the Denominations of his Piece, and parts thereof: which when he hath learned, which is the Baſe-ring, and Trunnion-ring, the Muſſel-ring, and the like, (you may ſee their names in the Figure of the Gun without more words;) and likewiſe the Crows, Handſpikes, the Coyn, and the like; and how far in the Bore is called the Chamber of the Piece: Theſe things underſtood, he may give them further directions; it is pity that the Gunners at Sea did not exerciſe the Sea-men in this knowledge, as the Corporal doth in Muſtering of them with their Muſquets; for want of this knowledge the greateſt part of common Seamen are ſo dull and ignorant, when they be required to ſtand by a great Gun in time of Fight.

Sect. II.

Who were the Inventors of Gun-powder, and ſome Principles of Philoſophy fit to be known.

Some *Italians* have writ that *Archimedes* the Philoſopher was the firſt Inventor of Guns and Gun-powder: Or whether this be truth or not Learned Men are of divers minds; *Munſter*, and *Gilbert Cognot* have written, that Guns were deviſed firſt in the year 1370 by a Monk, whom *Munſter* calls *Bertholdus*; but our Country-man Dr. *Dee* in his Mathematical Preface, that an *Engliſh-man* was firſt Inventor of Gun-powder in another Country, and they firſt made uſe of it from him; alſo our *Engliſh* Chroniclers do report, that in the year 1380 a Monk did accidentally let fall a ſpark of Fire upon Brimſtone and Salpeter beaten to powder in a Morter covered with a Stone, he ſeeing this mixture blow off the Stone from the Morter, did thereupon deviſe a kind of Powder, and taught the *Venetians* how to uſe the ſame in Pipes of Iron.

Every Simple Body is either Bright and Light, or elſe Groſs and Dark, and Ponderous, and according to the variety and difference, it is always naturally carried towards ſome one or other part; the World hath height as upwards, or depth as downwards.

All pure and rare bodies aſcend, as the Fire more than the Air; but the thick and groſs bodies deſcend, as the Earth more than the Water.

Nothing worketh naturally, but in that which is contrary to it, and more feeble; the form working, is aided by the Qualities; and the matter ſuffering, which ſuffereth by the Quality.

Nature is extremely curious, as well of her perfection, as her conſervation; and then when all things conſpire, as well the Action that cometh from the Agent, as the Paſſion from the Patient, hath proportion.

Accident hath its variety from the ſubject, and goeth not from one thing unto another.

Every Corporal thing repoſeth in its natural place; Nature admitteth no Empreſs.

A body rarifying it ſelf, the place thereof increaſeth as the body increaſeth; the reſiſtance of the moved proportional to the Mover furthereth the motion; the longer the Chace of a Piece, the louder the Report; the force of the ſtroke of a Shot dependeth on the ſwiftneſs of its motion.

Sect.

SECT. III.

The Description and Use of the Gunners Scale, upon which is all sorts of Ordnance, from the Canon to the Base, their Weight, Lading, Shot, and other things appertaining to them.

THis Scale is made according to the Diameter of our English Ordnance, 8 inches long, being the Diameter of a Canon-Royal; and it may be made of Silver, Brass, or Box, or any other fine-grained Wood, that will not warp. Upon one side are set the Names of all sorts of Ordnance, and in the Angle of meeting with the Names, is the Diameter of the Bore; and in the Angle of the Step is the common length of such Pieces; and upon the edge of the Step is how many Paces these Pieces shoot point blank, and joyning to the Line of the Diameter of the Piece, in their respective Columns is the weight of the Gun, the breadth of the Ladle; the length thereof; the weight of the Charge in Powder; the Diameter of the shot; the weight of the Shot; And then a Line of Inches; each Inch divided into 10 parts, and likewise into 8 *parts*, unto which the Lines of the Diameters of the bore are extended, also on the edge of the Rule there is a Line of Numbers, by which you work many useful Questions in Gunnery, as you will find in the following Pages.

The Use of this side of the Scale.

Suppose you come to a Piece of Ordnance, and it is desired to know what Piece it is, take the Scale, and put it into the Bore of the Piece, the step that fits it tells you the Name of the Piece, underneath you have the common weight of the Piece, the breadth and length of the Ladle, weight of Powder, Diameter of Shot, and weight thereof.

As for Example.

Admit I came to a Gun, and found by the former directions, that her Diameter of the Bore is 4 $\frac{1}{4}$ Inches. And I find her Name is *Demi-culverin* lower than ordinary; and 9 or 10 foot the usual length, and the Paces the Piece carries point blank are 174: and the usual weight 2000 *l.* breadth of the Ladle 8, and length 12 Inches, the weight of the Powder 6 $\frac{1}{4}$; and the Diameter of the Shot 4 inches; and the weight 9 *l.*

The Explanation of the Scale may serve likewise for the Table following; only take notice, that under Inches and Parts, the first figure to the left hand is Inches, and the other is so many 8 parts of an Inch.

As for Example.

Admit you enter the Table with a Saker of the lowest sort, the height of the Bore is 3 $\frac{5}{8}$ Inches, 8 foot long, the weight 1400, breadth of the Ladle 6 $\frac{5}{8}$, length 9 $\frac{6}{8}$ Inches, weight of the Powder 3 pound 6 ounces, Diameter of the Shot 3 $\frac{5}{8}$, weight of the Shot 4 pound 12 ounces, and the Paces the Piece carries (by *Alex. Bianco*'s Table) is 150 of 3 foot to the Pace.

Observe that the Ladle is but 3 Diameters of the Shot in length, and $\frac{1}{3}$ parts of the Circumference from the Canon; to the whole Culverin I allow the Charge of Powder to be about two Diameters of the Piece: From the Culverin to the Minion; the Charge to fill two Diameters and a half; all from the Minion to the Base three Diameters of Powder.

The Names of the Pieces of Ordnance.	Diameter of the Bore.		Length of the Gun.		Weight of the Gun in pounds.	Breadth of the Ladle.		Length of the Ladle.		Weight of the Powder.		Diameter of the Shot.		The weight of the Shot.		The Piece shoots point blank.
	Inches.	Parts. [8	Feet.	Inches.	Pounds.	Inches.	Parts. [8	Inches.	Parts. [8	Ounces.	Pounds.	Inches.	Parts. [8	Pounds.	Ounces.	Paces.
A Baſe.	1	2	4	6	200	2	0	4	0	0	8	1	1	0	5	60
A Rabanet.	1	4	5	6	300	2	4	4	1	0	12	1	3	0	8	70
Fauconets.	2	2	6	0	400	4	0	7	4	1	4	2	2	1	5	90
Faucons.	2	6	7	0	750	4	4	8	2	2	4	2	5	2	8	130
Ordinary Minion.	3	0	7	0	840	5	0	8	4	2	8	2	7	3	4	120
Minion of the largeſt ſize.	3	2	8	0	1000	5	0	9	0	3	4	3	0	3	12	125
Saker the loweſt ſort.	3	4	8	0	1400	6	4	9	6	3	6	3	2	4	12	150
Ordinary Sakers.	3	6	9	0	1500	6	6	10	4	4	0	3	4	6	0	160
Sakers of the oldeſt ſort.	4	0	10	0	1800	7	2	11	0	5	0	3	6	7	5	163
Loweſt Demiculverin.	4	2	10	0	2000	8	0	12	0	6	4	4	0	9	0	174
Ordinary Demiculverin.	4	4	10	0	2700	8	0	12	6	7	4	4	2	10	11	175
Elder ſort of Demiculverin.	4	6	10	0	3000	8	4	13	4	8	8	4	4	12	11	178
Culverins of the beſt ſize.	5	0	10	0	4000	9	0	14	2	10	0	4	6	15	0	180
Ordinary Culverin.	5	2	10	0	4500	9	4	16	0	11	6	5	0	17	5	181
Culverin of the largeſt ſize.	5	4	10	0	4800	10	0	16	0	11	8	5	2	20	0	183
Loweſt Demicanon.	6	2	11	0	5400	1	4	20	0	14	0	6	0	30	0	156
Ordinary Demicanon.	6	4	12	0	5600	12	0	22	0	17	8	6	4	32	0	162
Demicanon of great ſize.	6	6	12	0	5000	12	0	22	6	18	0	6	5	36	0	180
Canon Royal, or of	8	0	12		8000	14	0	24	0	32	8	7	4	58	0	185

The Deſcription of the other ſide of my Gunners Scale.

Upon the other ſide is a Scale of 8 Inches divided into four quarters, and betwixt each quarter above it is three Columns, wherein is the weight of all ſorts of Iron ſhots from 2 ounces to 71 ½ pound; and of Lead from 3 ounces to 106 pound ½, and of Stone from 1 ounce to 26 $\frac{10}{10}$ pounds; each diſtinguiſhed from other by their names, written in the firſt Inch, and the weights and meaſures, accommodated into our Engliſh *Averdupoiz* weight of 16 ounces to the pound, and to our Foot of Aſſize of 12 Inches to the Foot. The Line of Inches being likewiſe divided into 10 parts, the whole into 80, may ſerve for Protraction. There is alſo the Gunners Quadrant divided into 90 *degr.* in the outmoſt Limb, and in the ſecond Limb within, it is divided into the 12 points of the Gunner's Quadrant, and each point into 4 parts; and in the third Limb is a Geometrical diviſion of right and contrary ſhadows, for the ready taking of heights and diſtances; and there is alſo a Geometrical Quadrat, with each ſide divided into 10 parts, and each 10 parts divided into 10 more. The Uſe thereof in taking of heights and diſtances is in the 16 Chap. of the Second Book of the Deſcription of Inſtruments: But the Uſe for to level, or elſe to mount or Imbaſe any Piece of Ordnance, is in the 34 Section of this Book. To the ſide thereof is fitted a piece of Braſs of the ſame breadth as the Scale in thickneſs, with two holes within an inch of each end, and two Screws fitted to ſerve the four holes, as you may ſee in the Figure, that if you would level or mount any Piece of Ordnance, Screw the Plate to the end at B, with both Screws, and put the Plate in the bottom of the metal as far as he will go, and put the Tomping in upon him to keep the Plate faſt, and then level and mount your Piece, as in 33 Section directed: But if you will Imbaſe any Piece of Ordnance, you muſt ſcrew the Plate to the end A, and let the ſide with the Line of Numbers be next the Muzzle, and ſtop it with the Tomping, as before; then Imbaſe your Piece, or

put

put him under the Line of Level as you will, to what degree you pleaſe; and when you have done, ſcrew the Plate to the ſide A B, with a ſcrew at one end, and a ſcrew at the other. There is alſo over the weight of the Shot a diviſion of the right Ranges, and dead Ranges of Randoms of any Piece of Ordnance, upon any mounture from 0 degrees to 90 degrees. There is alſo a plain Scale, on which there is a Line of Chords, with the Gnomon-line, and a Line of ſix hours of the ſame Radius, and a Line of Rhumbs, with the Line of Sines; and this is for the making any Dial in any Latitude by the following directions, and alſo for the making any Triangle, or reſolving any Queſtion in Navigation, or Aſtronomy. There is alſo a Braſs Pin in the Center at C for to hang the thread and Plummet on.

SECT. IV.

The Uſe of the Line of Numbers on the Scale.

Knowing the weight of one Bullet, to find the weight of another Bullet, the height being given.

A Bullet of Iron of 6 Inches height, weigh: th 30 *l.* what will the like Bullet of 7 Inch s in Diameter (or height) weigh.

Extend the Compaſſes from 6 Inches to 7 Inches Diameter, the ſame diſtance will reach from 30 *l.* weight, turned three times over unto 47 *l.* 10 ounces, the weight of a Shot 7 Inches high.

The Arithmetical way.

$$\frac{30 \times 343}{216} = 47\ l.\ 10\ ounces\ \tfrac{1}{4}.$$

That is Cube 6 makes 216, and Cube 7 makes 343; then by the Rule of Proportion multiply 343 by 30, the Product is 10240, divide by 216, the Quotient is 47 pound, $\frac{1}{2}\frac{8}{6}$, which is 10 ounces.

By the Tables of Logarithms.

The Logarithm of 6 is	07781512
The Logarithm of 7 is	08450980
Subtract the uppermoſt Number out of the lower, the diff. increaſing.	0669468
	3
The triple of this difference is	2008404
Added to the Logarithm of 30 *l.*	14771212
Gives the Logarithm of the weight 47 $\frac{64}{100}$.	16779616

Now to know how many ounces $\frac{64}{100}$ is, work thus by the Rule of Proportion. If 100 gives 64, what will 16 ounces give? Anſwer, 10 ounces; ſo the Shot of 7 Inches Diameter weighs 47 *l.* 10 ounces or 47 $\frac{64}{100}$ pound, the like way of work is with all ſuch Queſtions.

SECT. V.

Admit the weight of an Iron Bullet being 30 pound, the Diameter is 6 Inches, the weight being 47 $\frac{64}{100}$ what is the Diameter?

DIvide the diſtance between 30 *l.* and 47 *l.* $\frac{64}{100}$ into 3 equal parts, and that diſtance will reach from 6 Inches to 7 Inches the Diameter required on the Line of Numbers.

By

By the Logarithms.

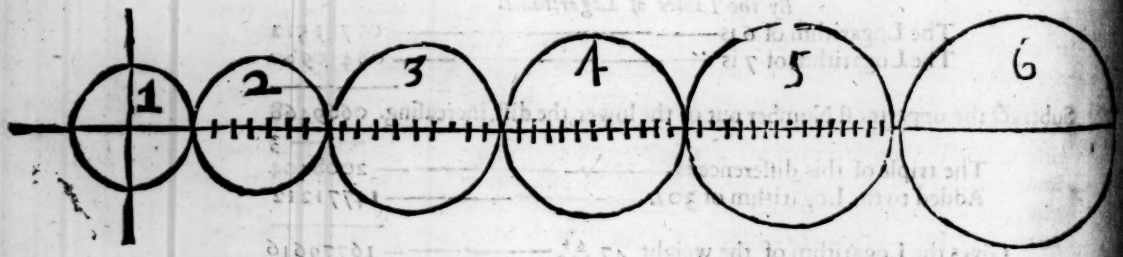
The Logarithm of 30 is	14771212
The Logarithm of 47 $\frac{84}{100}$ *l.* is	36779717
Uppermoſt Subtracted from it, leaves the difference increaſing	2008505
The difference divided by 3, or the third part of this difference	0669501
Added to 6 Inches Diameter, the Logarithm	7781512
Gives the Logarithm of 7 Inches Diameter required	08451013

Sect. VI.

The Geometrical finding the Diameter for the weight of any Shot aſſigned.

THis Rule ſhews the proportion of the Diameters according to any weight given, as having a Shot of one pound, 2 pounds, or 3 pounds weight of Metal or Stone aſſigned; if it be of one pound, divide the Diameter into 4 equal parts, and five ſuch parts will make a Diameter for a Shot of the ſaid Metal or Stone that ſhall weigh 2 *l.*

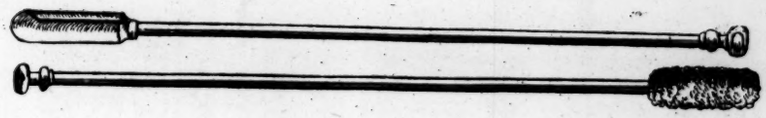
And divide the Diameter of a Shot that weighs 2 *l.* into 7 equal parts, and 8 ſuch parts will make a Diameter for a Shot of 3 *l.* weight; And divide the Diameter of a Shot of 3 *l.* weight into 10 equal parts, and 11 ſuch parts will make a Shot for 4 *l.* weight. And divide the Diameter for a Shot of 4 *l.* weight into 13 parts, 14 ſuch parts will make a Diameter of a Shot for 5 *l.* weight. And divide the Diameter of a ſhot of 5 *l.* weight into 16 equal parts, 17 ſuch parts will make a Diameter for a ſhot that will weigh 6 *l.* and ſo dividing each next Diameter into 3 equal parts more than the next leſſer was divided into, and it will with one part added give the Diameter of a ſhot that will weigh 1 *l.* more; and this is near the truth, being only Mechanical.

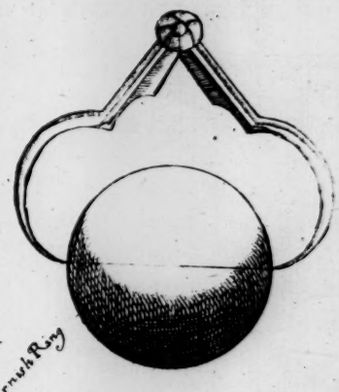


Note that the Diameter of a Shot of any weight being doubled is the Diameter of a Shot which weighs 8 times as much. Thus the double of the Diameter of 1 *l.* makes a Diameter of a ſhot of 8 *l.* and ſo the double of the Diameter of a Shot of 2 *l.* makes the Diameter of a Shot of 16 *l.* that is 8 times 2 *l.* and ſo the double of one of 3 *l.* makes the Diameter of a Shot of 24 *l.* and the double of 4 *l.* makes the Diameter of a Shot of 32 *l.* and ſo you may proceed as you pleaſe, and find the bigneſs of any Shot.

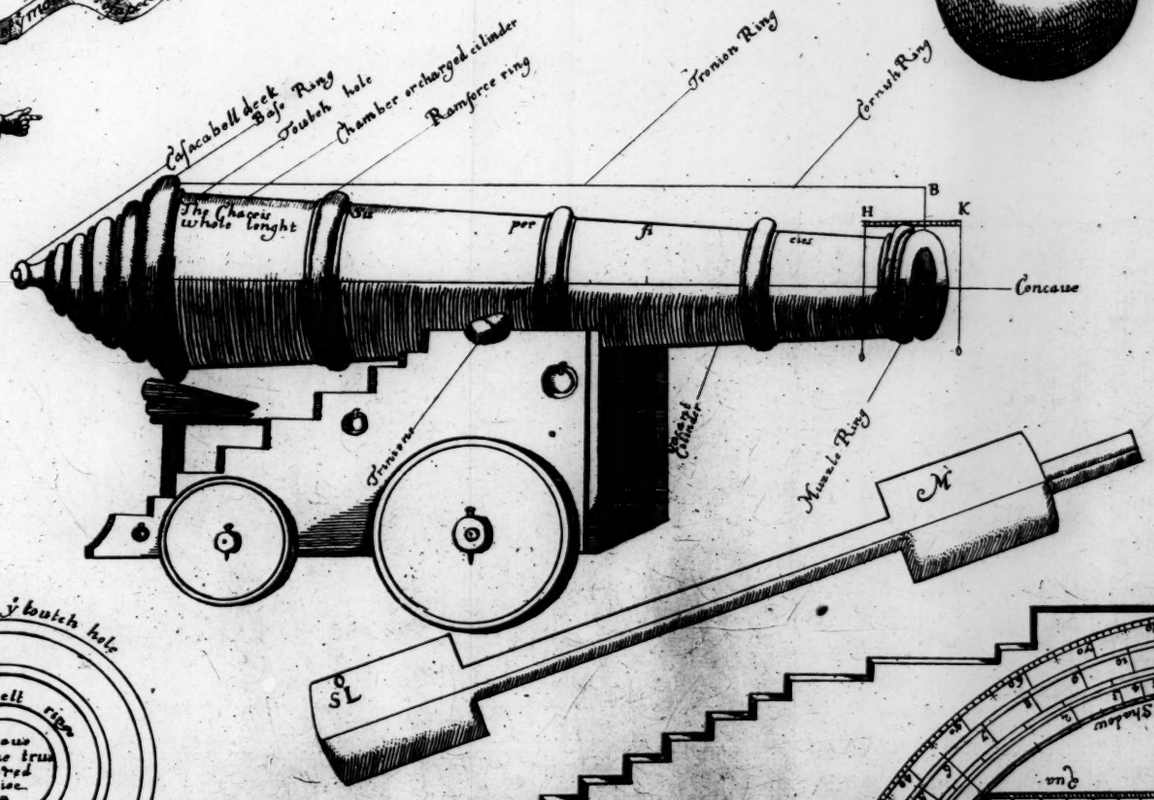
Note alſo, having the Diameter of a Shot of 1 *l.* double that Diameter it will make a Diameter of 8 *l.* and treble the Diameter of 1 *l.* will make a Diameter of a Shot of 27 *l.* and quadruple or 4 times the ſame will make a Diameter of a Shot of 64 *l.* and 5 Diameters will make a Ball of 125 *l.* and 6 Diameters of a Shot of 1 *l.* will make a Diameter of a Shot that will weigh 216 *l.*

Sect.

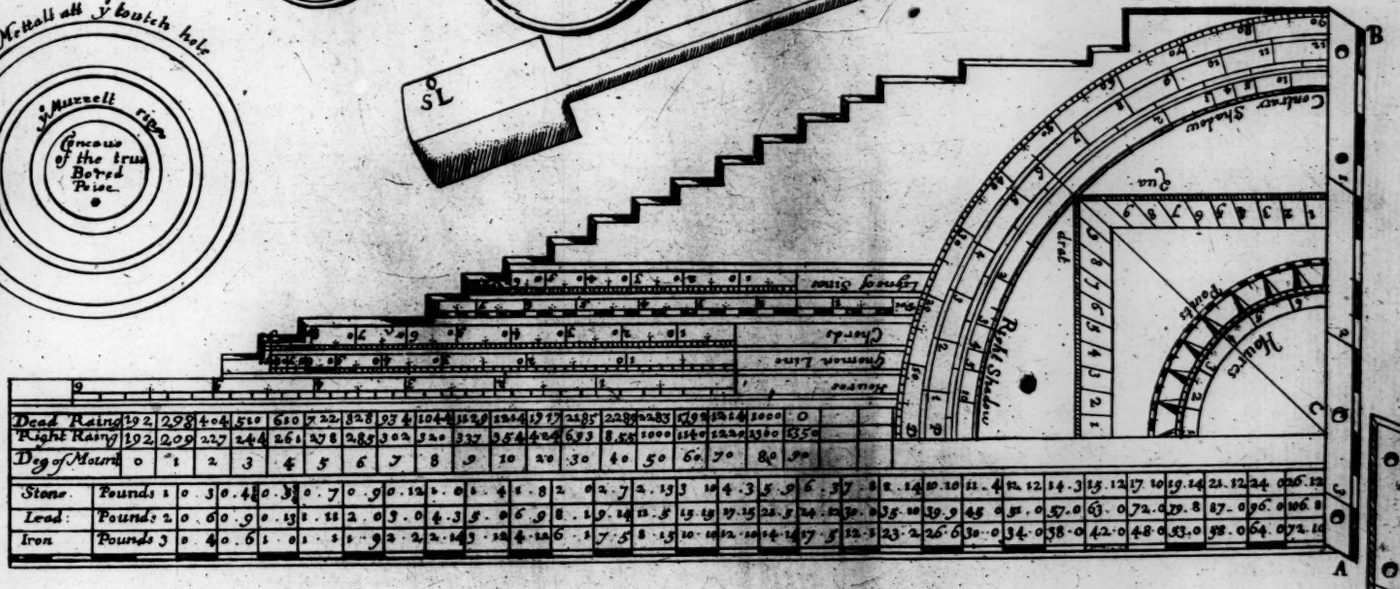


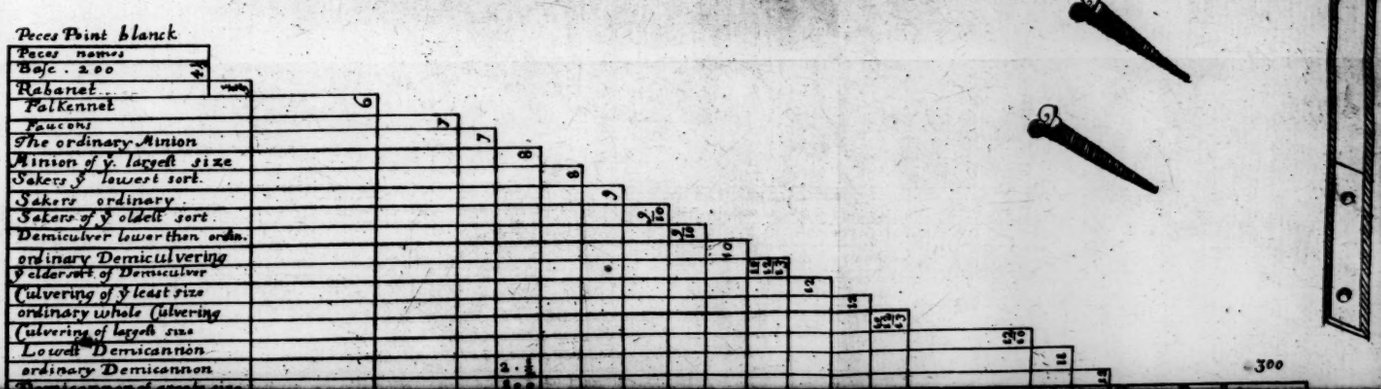


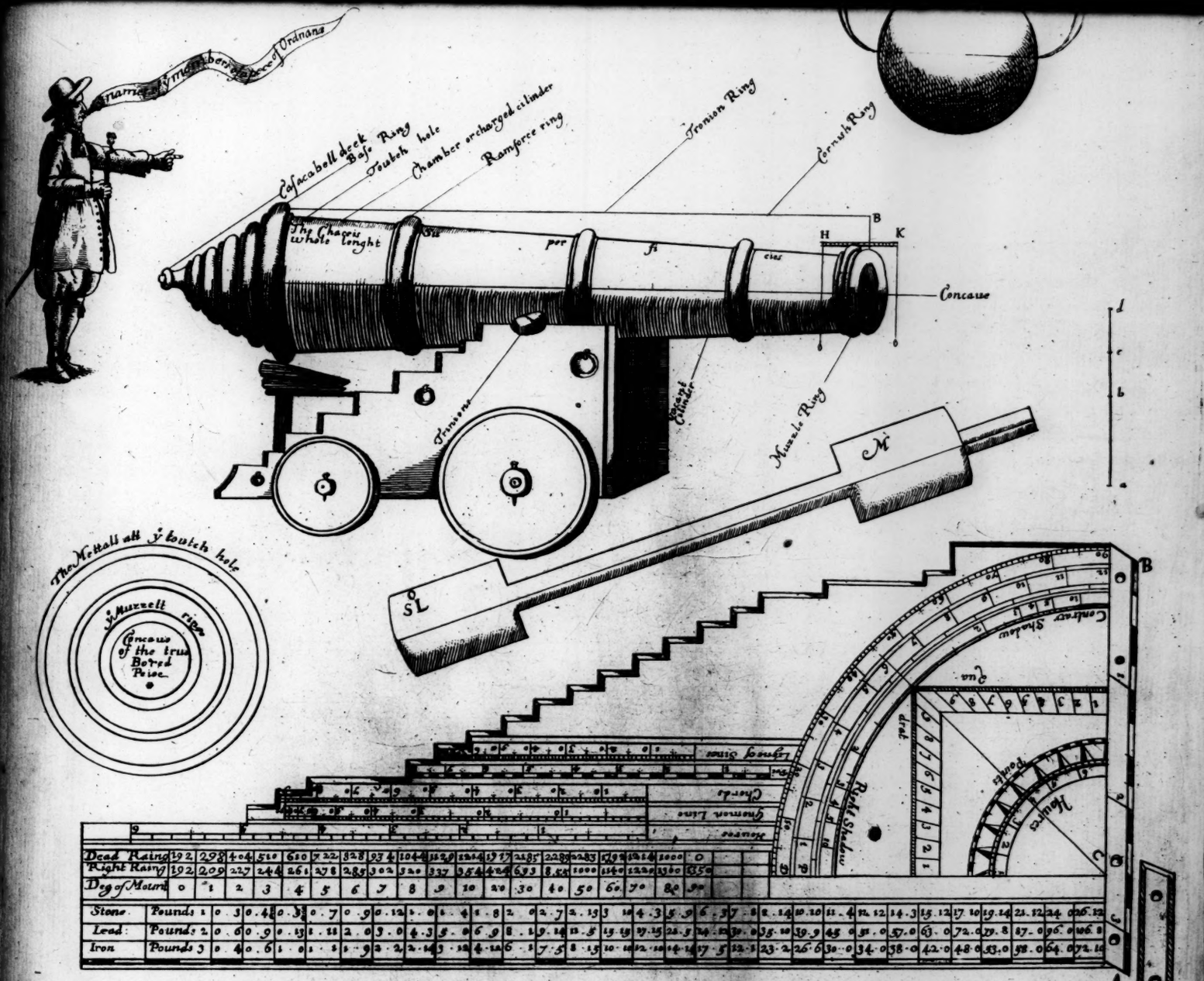

Transacted by members of the Office of Ordnans


Cascabell Cock
Base Ring
Touch hole
Chamber orcharged cilinder
Ramforce ring
Trunion Ring
Cornish Ring
The Chace in whole lenght
Concave
Trunions
Muzzle Ring
M
SL


The Mettall att ye touch hole
ye Muzzell ring
Concave of the true Bored Peice


Dead Raing 192 298 404 510 610 722 828 934 1044 1220 1414 1717 2185 2285 2285 4598 5214 1000 0
Right Raing 192 209 227 244 261 278 285 302 320 337 354 424 693 8.55 1000 1140 1222 1360 1550
Deg of Mount 0 1 2 3 4 5 6 7 8 9 10 20 30 40 50 60 70 80 90
Stone Pounds 1 0.3 0.4 0.5 0.7 0.9 0.12 1.0 1.4 1.8 2 0 2.7 2.15 3 10 4.3 5.9 6.3 7 0 8.14 10.10 11.4 12.12 14.3 15.12 17 10 19.14 21.12 24 0 26.12
Lead Pounds 2 0.6 0.9 0.15 1.11 2.0 3.0 4.3 5.0 6.9 8.1 9.14 11.5 13.15 17.15 20.5 24.12 30.0 35.10 39.9 45 0 51.0 57.0 63.0 72.0 79.8 87.0 96.0 106.8
Iron Pounds 3 0.4 0.6 1.0 1.5 1.9 2.2 2.14 3.12 4.12 6.1 7.5 8.15 10.10 12.10 14.12 17.5 20.5 23.2 26.6 30.0 34.0 38.0 42.0 48.0 53.0 58.0 64.0 72.12
Lignes Sines
Chords
Common Line
Sources
Rules Shadow
Contrary Shadow
Hours
Points
Dist
Qua


Peces Point blanck
Peces names
Base . 200
Rabanet
Falkennet
Faucons
The ordinary Minion
Minion of ye lagyest size
Sakers ye lowest sort
Sakers ordinary
Sakers of ye oldest sort
Demiculver lower then ordin.
ordinary Demiculvering
ye eldersort of Demiculver
Culvering of ye least size
ordinary whole Culvering
Culvering of lagyest size
Lowest Demicannon
ordinary Demicannon


Base Ring
Touch hole
Chamber or charged cilinder
Ramforce ring
Fronion Ring
Cornish Ring
The Chace in whole lenght
Concave
Trunions
Muzzle Ring
The Mettall att ỳ touch hole
ỳ Muzzell ring
Concave of the true Bored Piece
Dead Raing 192 298 404 510 616 722 828 934 1044 1152 1264 1376 1485 2288 2283 1598 1818 1000 0
Right Raing 192 209 227 244 261 278 285 302 320 337 354 424 493 858 1000 1140 1220 1300 1350
Deg of Mount 0 1 2 3 4 5 6 7 8 9 10 20 30 40 50 60 70 80 90
Stone Pounds 1 0.3 0.4 0.5 0.7 0.9 0.12 1.0 1.4 1.8 2 0 2.7 2.15 3 10 4.3 5.9 6.3 7 8 8.14 10.10 11.4 12.12 14.3 15.12 17 10 19.14 21.12 24 026.12
Lead Pounds 2 0.6 0.9 0.13 1.11 2.0 3.0 4.3 5.0 6.9 8.1 9.14 11.5 13 15 17.15 20.5 24.12 27.0 35.10 39.9 45 0 51.0 57.0 63.0 72.0 79.8 87.0 96.0 106.8
Iron Pounds 3 0.4 0.6 1.0 1.5 1.9 2.2 2.14 3.12 4.12 6.1 7.5 8.15 10.10 12.10 14.14 17.5 20.3 23.2 26.6 30.0 34.0 38.0 42.0 48.0 53.0 58.0 64.0 72.12
Peces Point blanck
Peces names
Base. 200
Rabanet
Falkennet
Faucons
The ordinary Minion
Minion of ỳ lagyell size
Sakers ỳ lowest sort.
Sakers ordinary
Sakers of ỳ oldelt sort
Demiculver lower then ordn.
ordinary Demiculvering
ỳ elder sort of Demiculver
Culvering of ỳ least size
ordinary whole Culvering
Culvering of lagyell size
Lowell Demicannon
ordinary Demiconnon
Demicannon of greate size
Weight of ỳ Gunn 300 400 750 750 1000 1400 1500 1800 2000 2700 3000 4000 4500 4800 5400 5600 6000 Cannon Royall 8000.
Breadth of ỳ ladle 2 2 1/2 4 4 1/2 5 5 6 1/2 6 1/2 7 1/2 8 8 1/2 9 9 1/2 10 11 1/2 12 12 14 1/2
Length of ỳ ladle 4 4 1/2 7 1/2 8 1/2 8 1/2 9.0 9 1/2 10 1/2 11.0 12 1/2 12 1/2 13 1/2 14 1/2 16 16 20. 22.0 22 1/2 24
Weight of ỳ Powder 0.12 1 2 1/2 2 1/2 3 1/2 3.6 4.10 5.0 6.0 7 1/2 8 1/2 10.0 11.6 12.8 14 17.8 18 32 lb. Foun
Diamiter of ỳ shott 1.3 2 1/4 2.5 8 2.16 3.0 3 1/2 3 1/2 3 3/4 4 4 1/2 4 1/2 4.3 5 5 1/2 6 6 1/2 6 1/2 7 1/2
Weight of ỳ shott 0.8 1.5 2 8.16 3 1/2 3.12 4.3/4 6.0 7.5 9.0 10.11 12.12 15.0 17.5 20 30 32 36 58
B R F.I F D.A A.L S.L S.O S.OL DCO nDC DC C.L O.C CG L.D.C. DDC DCG C.R.
Inches 1 2 3 4 5 6 7 8
300
Book .V. p 42.

SECT. VII.

To find what proportion is between Bullets of Iron, Lead, and Stone, by knowing the weight of a Shot of Iron; to find the weight of any other Shot of Lead, Braſs, or Stone of the like Diameter.

THe proportion between Lead and Iron, is as 2 to 3, ſo that a ſhot of 2 *l.* of Iron, is of like Diameter or height as 3 *l.* of Lead.

As for Example.

A ſhot of Iron of 6 Inches Diameter weighs 30 *l.* to find the weight of a ſhot of Lead of the ſame Diameter.

By the Rule of Proportion.

If 2 gives 30, what will 3 give? Multiply and divide, and the Quotient is 45, the weight of a ſhot of Lead.

2 — 30 — 3
3
90
x
2) 90 (45
xx

By the Logarithms.

The Logarithm of 2 is	03010300
The Logarithm of 30 is	14771212
The Logarithm of 3 is	04771212
	19542424
Log. of 45 *l.* the weight of the ſhot in Lead of the ſame Diam.	16532124

Extend the Compaſſes from 2 to 30, the ſame diſtance ſhall reach from 3 to 45.

The proportion between Iron and Stone is as 3 to 8; ſo that a ſhot of 30 *l.* of Stone is as big as the like ſhot of 80 *l.* of Iron; and 11 *l.* ¼ of Stone is of the ſame Diameter 6 Inches, as a ſhot of 30 *l.* of Iron, and 45 *l.* of Lead; the proportion between Lead and Stone is as 4 to 1; ſo that a ſhot of Lead of 40 *l.* is of the ſame height as a Stone ſhot of 10 *l.*

8 — 30 — 3
3
90
*x*2
8) 90 (11 ⅛
88

The proportion between Lead and Braſs is as 24 to 19.

The proportion between Iron and Braſs is as 16 to 18.

By theſe Rules aforegoing you may Calculate with eaſe, if Iron ſhot be wanting, and the other to be had, what weight any ſhot of Lead, Braſs, or Stone is to fit any Pieces of Ordnance; and by the ſame Rules here is a Table Calculated, and doth ſhew the weight of any ſhot of Lead, Iron, and Stone, from 2 Inches Diameter to 8 Inches, and quarters of Inches; the proper Stone for this purpoſe is Marble, Pibble, Blew hand Stone; (there may be a little difference of weight in ſome ſort of Stone: but theſe do nearly agree in weight;) you muſt remember in loading your Piece with a ſhot of Stone you muſt not have ſo much Powder as you do with Iron-ſhot, but abate according to the proportion that is between Stone and Iron.

The

The use of the Table, to find the weight of any Shot of Iron, Lead, or Stone from 2 to 8 Inches Diameter.

Inches.	Quart.	Iron. Poun.	Ounc.	Lead. Poun.	Ounc.	Stone. Poun.	Ounc.
2		1	11	10½	0	7	
2	1	1	92	6	0	9	
2	2	2	23	3	0	12	
2	3	2	144	5	1	1	
3		3	125	10	1	7	
3	1	4	127	2	1	13	
3	2	6	08	15	2	4	
3	3	7	511	00	2	12	
4		8	15	13	07	3	6
4	1	10	10½	16	0	4	0
4	2	12	10½	18	15	4	12
4	3	14	14	22	5	5	9
5		17	05	26	2	6	8
5	1	20	1	30	2	7	8
5	2	23	2	34	11	8	11
5	3	26	6	39	9	9	14
6		30	00	45	00	11	04
6	1	34	00	51	00	12	12
6	2	38	00	57	00	14	04
6	3	42	00	62	00	15	12
7		48	00	72	00	18	00
7	1	53	00	79	08	20	00
7	2	58	00	87	00	22	12
7	3	64	00	96	00	24	00
8		71	08	106	8	26	10

This Table is exactly Calculated, and the use thereof is very easie; we will make it plain by two Examples; I would know the weight of a Shot of 6 Inches, in Iron, Lead, and Stone: The first Column is Inches, the second quarters of Inches, the third Pounds and Ounces of Iron, fourth Pounds and Ounces of Lead, fifth Pounds and Ounces of Stone.

Enter the Table with 6 Inches Diameter in the first Column, and in that Line you shall have 30 pounds of Iron, 45 pound of Lead, 11 pound 4 ounces of Stone; And likewise, for 4 Inches ¼ Diameter the weight of an Iron shot is 14 pound 14 ounces, of Lead 22 pound 5 ounces, of Stone 5 pound 9 ounces; and so of the rest.

Sect. VIII.

How by knowing the weight of one Piece of Ordnance to find the weight of another Piece being of the same shape and fortification, and of the same Metal, or any other Metal.

First, with a pair of Crallapers take the greatest thickness of the Piece whose weight is known, at the Base-Ring; and also the Piece, whose weight you know not.

Example.

Admit a Brass Saker of 1900 weight, hath his greatest thickness 11 ½ Inches; Now I find the Diameter of the other Brass Piece, whose weight I know not, to be 8 ¼: Then proceed thus.

As

As the Logarithm greateſt Diameter 11 $\frac{1}{100}$ —— 006069
The Logarithm of the leaſt, 8 $\frac{11}{100}$ —— —— —— 0942 0

The Difference increaſing —— —— —— —— 11869
3
The triple of this Difference *Subtract* —— —— 35607
From the Logarithm of the weight given 1900 —— 327875

Reſt the Logarithm of 836, the weight required, —— 2,92228

Or extend the Compaſſes from 11 $\frac{1}{2}$ to 8 $\frac{11}{100}$ Inches Diameter, the ſame diſtance will reach from the weight given 1900 pound turned three times over to 836 pound.

The Arithmetical way.

C 8 $\frac{1}{4}$ x 1900
—— —— —— ==836 *l.* weight in Braſs.
C 11 $\frac{1}{2}$

But if the Piece had been Iron, whoſe weight you ſought, you muſt do as before with the Braſs, and find the difference of their Metals by the laſt Problem, which is as 16 to 18, then ſay by the Tables,

As the Logarithm of 18 —— —— —— —— 125527

Is to the Logarithm of weight in Braſs 836 —— 292220
So is the Logarithm of 16 —— —— —— —— 120412

412632

to the Logarithm of the weight in Iron 743 —— 287105

Or extend the Compaſſes from 18 to 836 the ſame diſtance will reach from 16 to 743 *l.* weight in Iron.

Arithmetical way.

X 836 by 16
—— —— —— ==743 *l.* of Iron.
18

Sect. IX.

How to make a Shot of Lead and Stone, the Stone being put in the Mould in which the Leaden Shot should afterwards be cast, to be of the like Diameter and Weight as an Iron Shot is of.

Inches.	Quart.	Lead. Poun.	Ounc.	Stone. Poun.	Ounc.	Both together. Poun.	Ounc.
1		0	1 $\frac{2}{3}$	0	0 $\frac{1}{3}$	0	2
1	$\frac{1}{2}$	0	6 $\frac{1}{4}$	0	1 $\frac{3}{4}$	0	8
2		0	14	0	4	1	2
2	$\frac{1}{2}$	1	12	0	8	2	4
3		3	2	0	10	3	12
3	$\frac{1}{2}$	5	0	1	0	5	0
4		7	7	1	8	8	15
4	$\frac{1}{2}$	10	8	2	2	12	10
5		14	7	2	14	17	5
5	$\frac{1}{2}$	19	4	3	12	23	0
6		25	0	5	0	30	0
6	$\frac{1}{2}$	32	0	6	0	38	0
7		40	0	8	0	48	0
7	$\frac{1}{2}$	48	0	10	0	58	0
8		59	0	12	0	71	0

If you take 5 parts of the weight of the Iron shot in Lead, and one part Stone, it will come near the matter. Here you have a Table how much Lead, and how much Stone must be together to make them equal to Iron Shot, from 1 Inch to 8 inches Diameter.

Sect. X.

How by knowing what quantity of Powder will load one Piece of Ordnance; to know how much will load any other Piece whatsoever.

ADmit you have a Saker of three Inches three quarters bore, and it requires 4 pound of Powder; what will a Demi-Canon of 6 $\frac{1}{3}$ Inches require? Work as follows.

As the Logarithm of 3 $\frac{75}{100}$ Diameter ——— 257403
The Logarithm of 6 $\frac{33}{100}$ Inches Diameter —— 281291

the difference increasing, ——— 23888
(3
The triple of the difference added ——— 71664
The Logarithm of 4 the Powder, ——— 060206

to the Logarithm of 20 $\frac{83}{100}$ *l.* of Powder — 131870

So that the Demi-Canon must have 20 *l.* $\frac{83}{100}$ or 13 ounces for her Charge of Powder.

By the Scale, extend the Compasses from 3 $\frac{75}{100}$ to 6 $\frac{33}{100}$ Inches Diameter, the same distance turned three times over from 4, will reach to 20 $\frac{8}{10}$ *l.*

The

The Arithmetical way.

$$\frac{C\,6\frac{1}{10} \times 4}{3\frac{11}{100}\,C} = 20\ l.\ 13 \text{ ounces of Powder for to load a Demi-Canon.}$$

You are likewise to understand that the Demi-Canon should be fortified as well as the *Saker*, therefore find the weight of the Demi-Canon as in Sect. 8. the weight of the Saker being 1600 *l.*

The Diameter of the Saker is $3\frac{11}{100}$ Inches	257403
The Demi-Canon Diameter is $6\frac{12}{100}$ Inches	281291
The difference increasing,	23888
The triple of the difference by (3)	71664
Added to the Logarithm of 1600 weight of Saker	320412
Gives the Logarithm of 8332 the Demi-Canon,	392076

But suppose the Demi-Canon to be no more than 6000 weight, then proceed thus to find the weight of Powder.

The supposed weight of the Demi-Canon 6000	377815
Add the weight of the Powder, if well fortified, is $20\frac{11}{100}$	131869
The Sum is	509684
Subtract the weight of the Gun well fortified 8332	392074
Leaves the weight of the Powder 15 *l.*	117610

Fifteen pound being a sufficient Charge for that Piece: Or extend the Compasses from 6000 to 8332, the same distance will reach from 20 $\frac{1}{10}$ to 15 *l.* of Powder, as before.

The Arithmetical way.

$$\frac{6000 \times 20 \text{ pound } 13 \text{ ounces.}}{8332} = 15 \text{ pound.}$$

Thus you are always to take care of over-loading your Piece, which error many run into, when they call a Piece a Demi-Canon, they presently load her with so much as is allowed for such a Piece so named, seldom examining whether the Piece have Metal enough for such a Charge, by which mistake they endanger their own lives, and others which stand near.

SECT. XI.

How to make a true dispert of any true bored Piece of Ordnance.

NOw we have found how to proportion Shot and Powder to any Piece of Ordnance true bored; before we Load and Fire, let us find the true Dispert to direct the Shot to the assigned mark.

By the same Rules you may find the Diameter of a Shot with a String.

With a pair of *Gallipers* (as in the Figure preceding) you take the Diameter of a Shot, and apply it to a Scale of Inches divided into 8 or 10 parts; so with the *Gallipers* take the greatest thickness or Diameter of the Base Ring, and by your Scale see how much that is; as admit that the length of the Line *a b c d*, were the Diameter of the Base Ring, then take the Diameter of the Muzzle Ring; as admit it be *a b*, then divide the difference *b d* into two equal parts, and one of them is the Dispert, put it upon the Muzzle of the Gun as C B, and stick it fast on the top of the Muzzle Ring with a little Pitch or Wax, and from the Base Ring at A in the

Figure to the top of the Diſpert at B, take aim to the Mark you would ſhoot to; but if *Callipers* be wanting, take a Stick that is ſtraight and flat, and two Strings with two Musket Bullets at their ends, and two Loops made at the other end, the Stick being ſomething more than the Diameter at the Baſe Ring, and put the Stick upon the top of the Ring at the Muzzle, as you ſee the Figure H K on the Gun, and put the Strings nearer and farther, until they only touch the Muzzle Ring, and mark the Stick, and put the Stick on the Baſe Ring, and do in like manner, and mark the Stick, and the Work will be the ſame, as it were taken by the *Callipers*, for the diſtance of the Notches on the Stick will give the Diameter of the Baſe Ring, and Muzzle Ring, and half the difference is the Diſpert, as before, if the Piece be true bored.

Another way to Diſpart a Piece of Ordnance.

If the Piece be not Chamber-bored, take the Priming Iron, and put it down in the Touch hole, until it reſt upon the Metal in the bottom of the bore, there make a mark on the priming Iron even with the Baſe Ring; likewiſe apply the Priming Iron to the bottom of the Metal at the Muzzle, and ſo much higher as the mark is which you made at the Baſe Ring, than the Muzzle Ring, ſo much is the Diſpert.

Sect. XII.

How to know whether your Piece be Chamber-bored.

Diſpert your Piece the firſt way, then with your Priming Iron take the Diſpert this laſt way; which done, compare it with the other Diſpert firſt found, and what it wants (being doubled) is the difference of the Chamber from the Bore of the Piece.

Admit the Diſpert found is three Inches, and by this laſt way is but two Inches, it ſhews that the Chamber differs from the true Bore on each ſide one Inch; ſo that if the Bore of the Piece be five Inches high, the Chamber being one Inch on each ſide lower, is but three Inches high: The like Obſervation we would always have you to make, that you may not afterwards be deceived in making Cartrages of Canvas and Paper to load the ſame.

Sect. XIII.

How to know what Diameter every Shot muſt be of to fit any Piece of Ordnance, or to chooſe Shot for Ordnance.

Take the Diameter of the Bore of the Piece, and divide into 20 equal parts, and one of thoſe parts is ſufficient vent for any Piece, the reſt of the 19 parts muſt be the height of the Shot; but now adays moſt Gunners allow the Shot to be juſt one quarter of an Inch lower than the Bore; which Rule makes the ſhot too big for a Canon, and too little for a Faulcon; but if the mouth of the Piece be grown wider, then the reſt of the *Cylinder* within by often ſhooting; to fit ſhot to ſuch a Piece, you muſt try with ſeveral Rammers-heads, until you find the Diameter of the Bore in that place where the Shot uſeth to lie in the Piece; and a ſhot of one twentieth part lower than that is fit for the Piece, therefore let Gunners remember to try the Piece, as directed.

Sect.

SECT. XIV.

How to find what Flaws, Cracks, and Honey-combs are in Pieces of Ordnance.

THis is a good way, as ſoon as you have diſcharged a Piece of Ordnance, cover the mouth of the Piece cloſe, and ſtop the Touch-hole at the inſtant time; if there be any unknown Cracks or Flaws which go through the Metal, a ſmoak will come through thoſe Cracks and Flaws; if not, the Gun is ſound.

There is a way to reflect the Sun-beams when he ſhineth, with a Looking-glaſs or Steel in at the hollow Cylinder of the Piece; for by this means a bright and clear light will be within, and by that light you will ſee every Flaw, Crack, or Honey-comb.

But by this way you may ſee at any time; take a Stick ſomething longer than the Piece, cleave the end of the ſaid Stick, for to hold an end of a Candle, light the Candle, and put it into the cleft end of the Stick, and put it into the Piece; by this light obſerve by degrees whether from the one end to the other there be any of the foreſaid Flaws, Cracks, or Honey-combs in the Piece.

This is a uſual way likewiſe, if in ſtriking a Piece upon ſeveral places of the Metal with a Hammer of Iron, you ſhall at any ſtroak hear a hoarſe ſound; then without doubt there is Honey-combs: but if in ſo ſtriking the Piece you ſhall at every ſtroak hear a clear ſound, then you may be ſure your Piece is clear of any Honey-combs, Cracks, or Flaws.

SECT. XV.

How to find whether a Piece of Ordnance be true bored, or not.

FIrſt, there muſt be provided a Staff, and two Rammers heads upon the Staff, and on the Rammers heads there muſt be two right Lines drawn upon them; to divide the two Rammer heads (that are the juſt height, and fit the bore) into two equal parts, and draw Lines on the Staff, that the Lines on the Rammer heads may ſtand alike, at one end, and at the other end, as you ſee in the Figure at L M. And let the Staff come through one of the Rammer heads about 9 Inches longer than the Cylinder of the Gun; then lay a flat Stick on the Muzzle Ring, and hold the ſide of the Quadrant (on the Gunners Scale) to the Stick, and by the String and Plummet find the middle, or upper and lower place of the Metal; then after you have found the upper and lower Point of the Metal, put the Rammer head L into the Gun, and let one hold it hard, and right with the Marks on the upper and lower part of the Metal with the Lines on the Rammer head above and below, whilſt you put a Priming Iron in at the Touch-hole, and ſtriking hard on the Rammer head, make a Mark; then pull it out, and apply the Line on the Rammer head to the Mark on the upper and lower edge of the Muzzle of the Gun, and you may preſently ſee how much the Mark is from the right Line of the Rammer head, to the right hand, or to the left; that is, if the Mark is juſt on the right Line, the bore is in the midſt: But if you find it a quarter of an Inch on the right or left hand, ſo much lieth the bore either to the right or left; and in ſhooting, the Piece muſt be ordered accordingly.

But now to know whether it is thicker upwards or downwards, or how the bore is, the way to know this, find the Diameter to the Piece at the Touch-hole with a pair of *Callipers*, then bend a Wire a little at the very end, that it may catch at the Metal when it is drawn out; after the Wire is fitted thus, firſt put it into the Touch-

Touch-hole till it touch the bottom of the Metal in the Chamber; then holding it in that place, make a mark upon the Wire, juſt even with the Touch-hole: afterwards draw up the Wire, until it catch at the Metal at the top of the Chamber; and there make a mark upon the Wire juſt even with the Touch hole: The difference betwixt the two marks is the wideneſs of the Chamber under the Touch-hole, and the diſtance between the firſt mark, and the end of the Wire, having half the Diameter of the Chamber of the Piece ſubtracted from it, will leave the half of the Diameter of the Piece at the Touch-hole if the Piece be true bored: But if this meaſure be more than half the Diameter, then the bore lyeth too far from the Touch-hole, and the upper part of the Metal is thickeſt; but if it be leſs, the under part hath moſt Metal.

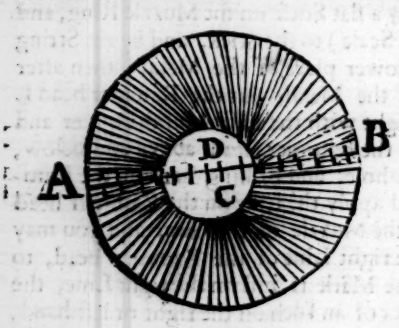
One Example will make it very plain.

Suppoſe that the Metal at the Britch be repreſented by A B C D, and the Metal at the Muzzle by *e f g h*, and the bore of the Piece I, whoſe Center is *l*, or the bore K, whoſe Center is *m*: and I find the Diameter of the Piece to be 15 Inches at the Touch-hole, the half thereof is $7\frac{1}{2}$ Inches. Then I find by a Wire the Diameter of the bore to be 5 Inches, but the bottom of the Metal is $10\frac{1}{2}$ Inches, half the Diameter of the bore being $2\frac{1}{2}$ Inches, which ſubtracted from $10\frac{1}{2}$ Inches leaves 8 Inches, which is $\frac{1}{2}$ Inches more than the Diameter of the Metal, that ſhews the Centre of the bore to be at R, and the thinneſt of the Metal is undermoſt, and there he is like to break firſt; beſides, it ſhews that you muſt add half an Inch to your Diſpert of a true bored Piece, to make a Diſpert for the Piece to ſhoot well: But if the bottom of the Metal had been found $9\frac{1}{2}$ Inches, then ſubtracting $2\frac{1}{2}$ Inches leaves 7 Inches; which is half an Inch leſs than half the Diameter of the Metal, and therefore the thinneſt part of the Metal is uppermoſt, and the Diſpert muſt be ſhortned half an Inch. View the following Figure.

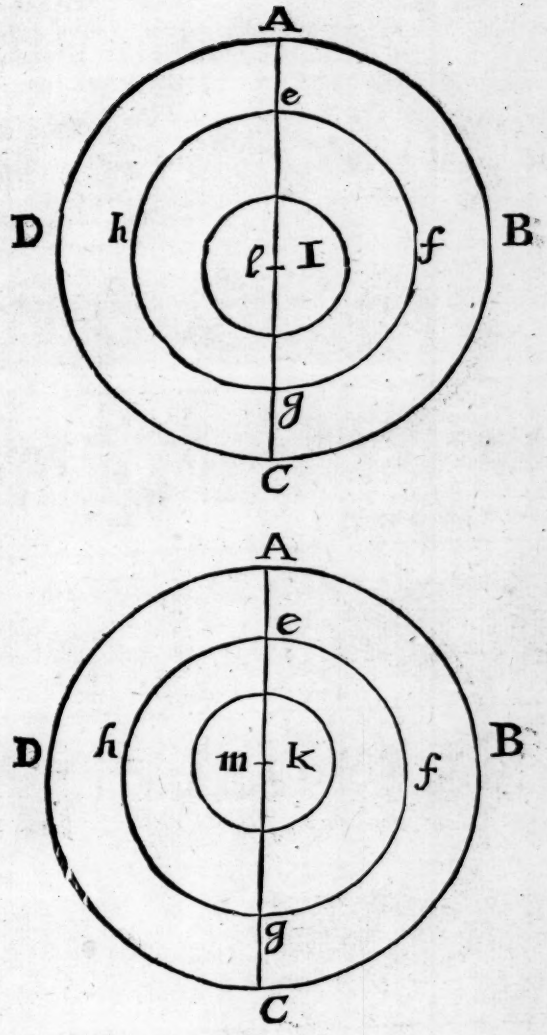
Sect. XVI.

To know what quantity of Powder ſhould be allowed to a Piece of Ordnance not truly bored.

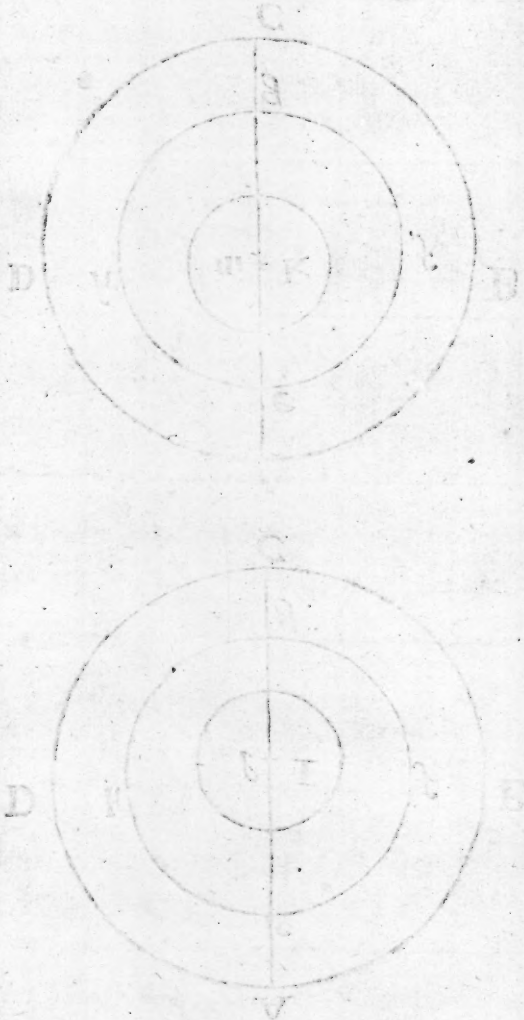
ADmit the Diameter of the Metal of the Piece at the Touch-hole be 16 Inches, and the Diameter at the bore is $5\frac{1}{4}$ Inches, the weight of the Piece 4850, ſuch a Piece requires 11 *l.* for her due Charge, (being near two Diameters of her bore in Powder:) But I find the ſoul or bore to be an Inch out of his place, or an inch from the middle of the Metal; then I conclude, that the thinneſt part of the Metal is 4 Inches $\frac{1}{8}$ parts, and the thickeſt ſide 6 and $\frac{1}{8}$ parts; by which it appears, that one ſide is juſt 2 Inches thicker than the other ſide, as you may ſee plainly by this Figure; in which the Line A B divided is the Diameter or greateſt thickneſs at the Touch-hole, every Diviſion repreſents an Inch from the inward Circle to the outward Circle, is the thickneſs of the Metal; the inward Circle repreſents the bore of the Piece, which you may ſee is an inch from the true bore or Centre of the outmoſt Circle; therefore you muſt work to find the weight of Powder as if the Piece were fortified no more than only ſo much as the thinneſt part of the Metal is, which here doth appear to be 4 inches $\frac{1}{8}$ parts, which doubled makes $8\frac{1}{4}$ to which add the Diameter of the bore $5\frac{1}{4}$ makes 14 inches, which call the leſſer Diameter.



The



Page 52. of Gunnery.


C
D
D
E
C
D
D
V

To find the weight of Powder proceed thus.

The Logarithm of greateſt Diameter 16 is	220412
The Logarithm of the leſs Diameter 14	214612
The difference decreaſing	5800
	(3
The triple of the difference Subtracted	17400
From the Logarithm of 11 *l.* Powder	204139
Leaves the Logarithm of the Powder 7 $\frac{6}{10}$ *l.*	186739

So that 7 pound $\frac{6}{10}$ or 6 ounces is a ſufficient Charge for ſuch a falſe bored Piece; or extend the Compaſſes from 16 to 14, the ſame diſtance 3 times repeated from 11, will reach 7 $\frac{6}{10}$ pound, as before.

The Arithmetical way.

C 14 is | 2744 x 11
——— ——— ——— = 7 pound 6 ounces, as before.
C 16 is | 4096

SECT. XVII.

How Mouls, Forms, and Cartrages, are to be made for any ſort of Ordnance.

CArtrages are uſually made of Canvas or Paper-Royal; to make them, firſt take the height of the bore of the Piece, and allow $\frac{1}{22}$ part of the Diameter for the Vent, and make the breadth of your Cartrages three Diameters of the Chamber of the Piece, beſides the ſewing or paſting, and from the Canon to the whole Culverin is allowed about two Diameters of the Piece, from the Culverin to the Minion the Charge is the length of two Diameters $\frac{1}{2}$, and all from the Minion to the Baſe three Diameters of Powder, but make them at firſt about four Diameters long, and according to the directions here given mark them; or put a pound of Powder into each Cartrage, and meaſure how full it fills it by your Scale for each Gun, and ſo you may know how to mark the Cartrage for the full loading, or diminiſhing of your Powder, according to the goodneſs or badneſs thereof; and for the extraordinary over-heating of the Piece. Having reſolved what ſort of Ordnance are to ſerve you, accordingly have a form of Wood turned to the height of the Cartrage, which is the $\frac{1}{22}$ part of the Diameter of the bore and half an Inch longer than the Cartrage; before you paſte your Paper on the Form, firſt tallow it, ſo will the Canvas or Paper ſlip off without ſtarting or tearing; if you make for taper bored Guns, your Forms muſt be accordingly tapered; if you make Cartrages of Canvas, allow one inch for the Seams; but of Paper $\frac{3}{4}$ of on inch (more than three Diameters) for the paſting. When your Cartrages are upon the former, having a bottom ready fitted, you muſt paſte the bottom cloſe, and hard round about, then let them be well dried; and mark every one with Black or Red Lead, or Ink, how high they ought to be filled; and if you have no Scales nor Weights, theſe Diameters of the Bullets make a reaſonable Charge for the Canon 2 $\frac{1}{4}$, for a Culverin 3, and for the Saker 3 $\frac{1}{2}$, for the leſſer Pieces 3 $\frac{1}{4}$ of the Diameter of the Bullet, and let ſome want of their weight againſt the time they are over-hot, or elſe you may endanger your ſelf and others.

SECT.

Sect. XVIII.

How to make Ladles, Rammers, or Spunges for all ſorts of Ordnance.

EVery Maſter Gunner ſhould know how to Trace, cut out, and alſo make up and finiſh all Ladles, Spunges, and Rammers, and direct others how to make, and finiſh the ſame ready for uſe.

You have in the Table in the third Section the length and breadth of the Ladle, anſwerable to each Gun in inches and parts, and you muſt allow half a Diameter more to incloſe the head of the Staff within the Plate; the Button, or head of the Ladle-ſtaff muſt be the height of the Shot almoſt; for Spunges, their bottoms and heads are to be made of ſoft wood, as Aſp Birch, Willow, to be one Diameter $\frac{1}{4}$ in length, and $\frac{3}{4}$, or a very little leſs of the height of the Shot, and covered with Sheep-skins, and nailed with Cooper's Nails, that together they may fill the concave of the Piece.

Let the Head of the Rammers be of good hard Wood, and the height, (as before) one, and the length $\frac{1}{3}$ of the Diameter of the Shot at one end next the Staff, it muſt be ſo turned, that a Ferril of Braſs may be put thereon, to ſave the Head from cleaving, when you Ram home the Shot, the Buttons or heads muſt be bored $\frac{2}{3}$ for the Staff to be put in, and faſtned with a Pin through, and the Staffs length a Foot more than the concave of the Gun.

To make a Ladle for a Chamber-bored Piece, your Compaſſes opened to juſt the Diameter of your Chamber within $\frac{1}{8}$ part of an Inch, divide the meaſure into two equal parts, and with that diſtance draw a Circle on a Slat or Paper, and take $\frac{1}{3}$ parts of the Circumference of that Circle for the breadth of the Plate of the Ladle; and for Cannons, the length ought to be ſuch as at twice to hold the juſt quantity of Powder, Rammers and Spunges for Sea ſervice, are made of four-ſtrand rope, well ſerved with Spun Yarn that they may be ſtiff for uſe.

Sect. XIX.

How the Carriage of a Piece ſhould be made.

MEaſure the length of the Cylinder of the bore, and once, and half that length ſhould be the length of the Carriage, and in depth four Diameters of the bore of the Piece at the fore-end, in the middle 3 and $\frac{1}{2}$, and at the end next the ground 2 and $\frac{1}{2}$, the thickneſs the Diameter of the Shot; the Wheels ſhould be one half the length of the Piece in height; the Saker and Minion muſt exceed the former by $\frac{1}{2}$ part, the *Falcon* and *Falconet* by one ſixth part. Sea-Carriages are made leſs, and of another form.

Sect. XX.

To know whether the Trunnions of any Piece of Ordnance are placed right.

MEaſure the length of the Cylinder of the bore from the Muzzle to the Britch, Divide the length by 7, and multiply the Quotient by 3, and the Product will ſhew you how many inches the Trunnions muſt ſtand from the bottom of the bore of the Piece, and you muſt know that the Trunnions ought to be placed, ſo that $\frac{2}{3}$ of the Piece may be ſeen above the Center of the Trunnions.

Sect.

SECT. XXI.

How much Rope will make Britchings and Tackles for any Piece.

IN Ships that carry Guns, the moſt experienced Gunners take this Rule. Look how many foot your Piece is in length, four times ſo much is the length of the Tackle, and their Britchings twice the length and if the Ropes be ſuſpected not to be good, they nail down Quoyns to the Fore-Trucks of heavy Guns, that they may have no play; and if Britchings, and Tackles, and Quoyns ſhould give way in foul weather, preſently diſmount her, that is the ſureſt way.

SECT. XXII.

What Powder is allowed for Proof, and what for Action of each Piece.

FOr the biggeſt ſort of Pieces as Canons; for Proof $\frac{4}{5}$, and for Service $\frac{1}{2}$ the weight of her Iron Shot, for the Culverin the weight of the Shot almoſt for Proof, and for Action $\frac{2}{3}$, for the Saker and Faulcon, for Proof the weight of the Shot, and for action $\frac{4}{5}$, and for leſſer Pieces the whole weight of the Shot, for ſervice and for Proof give them one and $\frac{1}{3}$ of the weight of the Bullet in Powder.

SECT. XXIII.

The difference between the common Legitimate Pieces, and the Baſtard Pieces, and extraordinary Pieces.

GUnners call them Legitimate Pieces, that have due length of their Chaſe according to the height of their bores, Baſtard Pieces are ſuch as have ſhorter Chaſes than the Proportion of their bore doth require; and Extraordinary, are ſuch Pieces as have longer Chaſes, than the proportion of their bore alloweth; and theſe are called Baſtard Canons, Culverins; and ſo likewiſe of Saker and Faulcon, which by your Scale, and the Rule thereon, you may preſently find.

SECT. XXIV.

How Powder is made, and ſeveral ways to know whether Powder be decayed or no, by moiſture or age, in part, or in whole.

POwder was always made of Salt-peter, Brimſtone, and Charcole; but in theſe latter times experience hath ſtill mended the goodneſs or ſtrength of it more than it was in former times by much: The beſt ſort that is made at this preſent time is made of ſix parts Saltpeter, Brimſtone one part, and Charcoal one part. The common Piſtol Powder is now made of Saltpeter five parts, one part of Brimſtone, and one of Coal; Canon-Powder of Saltpeter four times as much as of Brimſtone, and as of Coal. The reaſon why Piſtol-Powder being the ſtrongeſt is not ſo good for the Cannon as the Cannon Powder which is the weakeſt, although you take but ſo much of the Piſtol Powder as you find to be of like ſtrength with that quantity of Cannon-Powder fit for the Charge of the Piece: And the reaſon why Cannon-Powder is beſt for Ordnance, is, becauſe it taketh up a greater room in the Cylinder of the Piece than Piſtol-Powder; and ſo it hath the greater length or fortification of Metal about it in the Piece.

This *Nathan Nye*, Maſter Gunner of *Worceſter*, found by an experiment made by him at *Deriton* the 17 of *March* Anno 1644, he loading a Saker-bore Piece of Iron, the thickneſs of the Metal about the Chamber was 2 Inches, with 4 pound of weak Cannon-Powder, which filled the Cylinder of the bore 9 inches juſt. He fired, and the Piece went off ſafe; and he ſaith, he loaded her again with one pound and $\frac{1}{4}$ of fine Powder almoſt, which filled the bore but 2 inches and $\frac{1}{4}$, and when the Gun was diſcharged, it broke into divers pieces, as there is witneſs enough in that Town.

How to know good Powder.

The harder the Corns of Powder are in feeling, by ſo much the better it is. Secondly, Gunpowder of a fair Azure or French Ruſſet colour is very good, and it may be judged to have all its Receipts well wrought, and the proportion of Peter well refined. Thirdly, Lay three or four Corns of Gun-powder upon a white piece of Paper, the one three fingers diſtant from the other, and fire one, if the Powder is good, they will all fire at once, and leave nothing but a white chalky colour in the place where they were burned, neither will the Paper be touched; but if there remains a groſneſs of Brimſtone and Saltpeter, it is not good. Fourthly, If you lay good Powder on the Palm of your hand, and ſet it on fire, it will not burn you. Fifthly, To know the beſt amongſt many ſorts of Powder, make a little heap of every ſort, and then ſetting thoſe heaps one from the other, mark well when you put fire into them, which of the heaps did take fire the ſooneſt; for that Powder that will ſooneſt be on fire, ſmoak leaſt, leave leaſt ſign behind it, is the beſt ſort of Gun-powder.

Sect. XXV.

How to make an excellent good Match to give fire to any Ordnance.

TAke Cords made of Hemp that is not very fine, or of Tow which is better, (although it will conſume ſooner,) and twiſt it until you have made the Strands as big as a mans little Finger; this done, boyl the ſaid Cords in ſtrong Lye aſhes, and a little Saltpeter, until all the Lye be waſted, and then make it up, and take the *Feces* or remainder into your hand, and through it draw the Match twice or thrice, then dry it, and keep it for ſpecial uſes, for Vaults, Mines, and moiſt weather, for it is very fit for your uſe any where.

Sect. XXVI.

How to make Powder that will not waſte with time, and preſerve that which is good from decaying.

THat time ſhall not waſte it, take what quantity of Powder you will, and mix it with Brandy, and make it up in Balls, and dry them well in the Sun, or in a warm place, and keep them in Earthen Pots well glazed until you have occaſion to uſe them; this Powder will not waſte with age, nor decay.

To preſerve Powder that is good, all Gunners have, or ſhould have that reaſon to keep their Powder and Store in as good a dry place as is to be had in Fort or Ship convenient, and every Fortnight, or at moſt three weeks, turn all the Barrels, and Cartrages (Barrelled up for readineſs) upſide down, ſo will the Peter be diſperſt into every place and part alike; for if it ſhould ſtand long, the Peter will deſcend downwards always as it lies, and if it is not well ſhaked and moved, it will want of its ſtrength at top very much, and one Pound at bottom, with long ſtanding, will be ſtronger than three at the top. Keep all Cartrages which are filled for the Piece againſt it is hot in Barrels by themſelves, that you may know them by a mark when need requires.

Sect.

SECT. XXVII.

To renew and make good again any ſort of Gun-powder that hath loſt its ſtrength by long lying, or moiſture, or any other means.

FIrſt moiſten the ſaid Gun-powder with Vinegar or fair water, beat it well in a Mortar, and then ſift it through a fine Sieve, or a Search, with every pound of Gun-powder mingle one ounce of Salt-peter that hath been mealed; and when you have ſo done, beat and moiſten this mixture again, until you ſee by breaking or cutting with a Knife that there is no ſign of Saltpeter in it; moreover to corn this Powder when it is incorporated with the Peter as it ought to be, prepare a Sieve with a bottom of thick Parchment made full of round holes; then moiſten the Powder, which ſhall be corned, with Water, put the ſame, and alſo a little Boul into the Sieve; and when you have ſo done, ſift the Powder ſo as the Boul rolling up and down in the Sieve may break the clods of Powder, and make it by running through the holes to corn; and that which will not go through, you muſt beat it again until it will.

SECT. XXVIII.

To make Powder of divers Colours, and firſt to make White Powder.

TAke of Saltpeter 12 parts, of Brimſtone two parts, and of Camphir one part, beat, and ſift, and incorporate all theſe things together; and after you have ſo done, beat them again, and ſo oft until you are ſure they are well incorporated, then moiſten it with *Aqua Vitæ*; and when you have thus done, corn the Powder, as you are taught before.

To make Red Powder.

Take the ſame things, and work them as before directed for White Powder, and as that was moiſtned with *Aquavitæ*, now you muſt moiſten this with Vinegar, being firſt boyled with Braſil wood until it be red as bloud, which will make the Powder likewiſe ſo in moiſtening of it, and then corn it, as is before taught.

To make any coloured Powder.

Boyl the Vinegar in ſuch tranſparent Colours as you would have the Powder to be of, as if Blue with blue Bice, of Green with a little Verdigreace, and the like: always take care that the Colour be not too thick, but very thin, or elſe it will weaken the Powder that you make.

SECT. XXIX.

Of ſeveral ſorts of Saltpeter, and a way how to make a ſort of Saltpeter very excellent, with eaſe, and leſs coſt than any way.

ARtificial Saltpeter is a mixture of many ſubſtances gotten with Fire and Water out of dry Dirt and Earth, as out of Vaults and Tombs, and alſo Charnel-Houſes: the beſt of all is of Beaſts-dung converted into Earth, in Stables, or Dung-hills of a long time not uſed; and when it is to be made, it is made with a great deal of Charge. Another excellent ſort of Saltpeter is made on Flower that is called Plaſter that groweth on Walls four parts, of unſlaked Lime one part, and ſo boiled over the fire with Water, and proceed as is uſual in making Saltpeter. But this one way, which is the moſt eaſie and leaſt coſt, I will ſhew you.

Take quick Lime, and pour warm water upon it, and let it ſtand ſix days, ſtirring it twice or thrice a day; take the clear of this water, and ſet it in the Sun until it be waſted, and the Saltpeter will remain in the bottom. To refine Saltpeter, and make it fit for uſe, there is ſeveral ways, but this by fire I ſhall only write of. Do thus: take an Iron Pot or Skellet and fill it with Peter, ſet it on the Fire, and cover it cloſe with an Iron Cover, or with a Stone; when the Saltpeter is melted, take Brimſtone moſt finely beaten, and caſt ſome thereon; kindle it, and let it burn until all the upper part be burned, which will leave the Saltpeter cloſe like to a piece of Marble, for the Brimſtone will burn up the greaſineſs of the Saltpeter. It is to no purpoſe to give a further relation of this, by reaſon every Gunner may have his Peter ready made, refined, and in Meal at the Ship Chandlers; or if he is conſtrained to make Peter or Powder, he may have ſeveral Books which give a full and large deſcription of the making thereof, as *Nath. Nye*, *Tartaglia*, or *Norton's* Gunnery, to which I refer them.

Sect. XXX.

How to load and fire a Piece of Ordnance like an Artiſt.

To load your Piece, firſt obſerve the Wind, and be ſure to lay your Budge-Barrel, or Cartrage of Powder to Windward of your Piece, and place your Linſtock to Leeward, clear the Touch hole, and Spunge her well, and ſtrike the Spunge on the Muzzle to ſhake off the foulneſs two or three blows. Stand on the right ſide of the Gun, and let your Aſſiſtant hold the Barrel aſlope, ſo that you may thruſt in the Ladle; being full, give it a ſhog, then ſtrike off the heaped Powder, he being on the right ſide likewiſe, with your Body clear of the Muzzle, put the Ladle home to the Chamber ſteadily holding your Thumb upon the upper part of the Ladle-ſtaff, then turn the Staff until your Thumb be under it, and give a ſhake or two to clear the Powder out of the Ladle; as you draw it out, keep it up that you may bring no Powder out with the Ladle; then with the Rammer put the Powder home gently, and after put in a good Wad, and thruſt it home to the Powder, and give it two or three ſtroaks, to gather the looſe Powder together, and it will fire the better; be ſure your aſſiſtant have his Thumb on the Touch-hole all the while; then put in the Shot home with the Rammer, and after it another Wad, and then with the Rammer give two or three ſtrokes more to ſettle it home, that there may be no vacuity between the firſt Wad, Bullet, and laſt Wad; ſtanding to Windward, and your Piece (by the Diſpert) directed to the Mark, Prime her, and let the Powder come from the Touch-hole to the Baſe-ring, your Leg ſtanding forward, and fire the Powder on the Baſe-ring, and draw back your hand, and you have fired like a Gunner; but if you had given fire upon the Touch hole, the Powder there would have endangered to have blowed the Coal and Linſtock of your hand; therefore you muſt have a care of a great Touch-hole.

Sect. XXXI.

The difference of Shooting by the Metal, and by a Diſpert.

Shooting by the Metal.

Shooting by the Metal, as in the Figure A B, is thus, admit you raiſed the Muzzle-ring, and the Baſe-ring, and the Mark, with your Eye in a Right-line, if you put the Gunners Scale into the Muzzle with the Plummet hanging to it, you ſhall find it elevated, which will be more or leſs according to the length of the Piece, and in regard of the ſeveral differences of the length and Diameter of her Baſe and Muzzle-ring, no certain proportion can be aſſigned for the Randoms, but they vary according to the length of the Piece.

Sect.

SECT. XXXII.

How to direct a Piece, to amend an ill Shot that was made, by a Diſpert.

AFter you have made one Shot, and find the Piece carry juſt over the Mark, then load your Piece as hath been before taught, and when your Piece lies directly againſt the Mark, obſerve how much the laſt ſtroke of the Shot appears above the Mark, ſo much longer make your Diſpert, that the top of it may be juſt ſeen from the Britch of the Piece in a direct Line with the ſtroke of the Shot; and then Level your Piece with this new Diſpert to the aſſigned Mark, give Fire, and it may prove a good Shot, if the firſt Shot had ſtruck under the Mark, then bring the Piece in all points as before; mark how much the Diſpert is over the Shot, and cut it juſt ſo ſhort, as being at the Britch, you may diſcern the top of it, the Mark of the Baſe-Ring, and the ſtroke of the Shot in a Right-line, when you perceive it is of ſuch a length, level the Piece to the intended Mark as at the firſt, Prime, and give fire.

If the firſt ſhot had ſtruck on the right hand of the Mark, to mend it you muſt level the Piece as formerly, you ſtanding behind the Britch of the Piece, obſerve the ſtroke of the Shot over the Diſpert, and what part of the Baſe-ring you ſaw in a Right line with the Diſpert, and the ſtroke of the Shot, ſet up a Pin with a little ſoft Wax there on the Baſe-ring, then level your Piece to the Mark intended by this Pin, and the firſt Diſpert, and you may make a fair ſhot; for when you level by the Metal of the Baſe-ring where the Pin is placed and the Mark; look over the top of the Diſpert from the Mark in the Baſe-ring, and you ſhall find the Piece to lie juſt ſo much to the left, as the former Shot ſtruck to the right from the intended Mark, which ſhould in all likelihood prove a good ſhot, unleſs there be ſome other impediment.

But if the Shot be both wide and too low, then you muſt uſe both directions, as before taught to make the next ſhot; firſt regulate the Diſpert by cutting it ſhorter, according as the Mark of the ſhot is lower than the intended Mark, then by the laſt Rule mend the ſhooting wide; theſe things done with care and diligence, you may be ſure will mend a bad ſhot.

SECT. XXXIII.

Of ſhooting by Elevation or Random at a Mark,

THe Random of a Piece is the whole diſtance from the Platform upon which the Piece is diſcharged unto the firſt fall or graze of the Bullet on the Level-line; or on the ground called the Horizontal Plain. Now it is very difficult, and a thing uncertain to arrive herein unto exactneſs without much experience of the Piece; and therefore every one that will learn to ſhoot at Random muſt draw his Piece into a level ground, where firſt ſhooting level, he muſt obſerve that diſtance in Feet and Paces; then mount his Piece to one degree, and mark where that doth graze, and thus find the diſtance of every degree from the Level to the tenth degree, or as high as the Piece will mount; and by theſe diſtances make a Table, to which annex the degrees againſt the diſtances, by which Table, and the Rule of Proportion, you may find how far another Piece will convey her Shot from degree to degree; but in caſe you cannot have the liberty, nor Powder to do that, you ſhall have a Table here that was made out of a Saker eight Foot long (by *Nath. Nye*, as in the fortieth Chapter of his Book) where he ſaith, he loaded her with three pound of Powder, the Shot at one degree of mounture was caried 225 Paces; the next Shot was at five degrees Random, and at that mounture the Shot was conveyed 416 Paces; and the next trial was at ſeven degrees mounture, and the Random was 505 Paces; the laſt trial was at ten degrees mounture, which ſent the Shot 630 Paces, of five Foot to a Pace.

Whilſt

Whilſt he made theſe Shots, he loaded the Piece himſelf with looſe Powder, exactly weighed, and weighed the Wad alſo, and beat down the ſaid Wad with four ſtrokes ſo near as he could by the ſame ſtrength, as he did the time before; alſo he let the Piece cool betwixt each Shot of it ſelf, ſtaying above half an hour betwixt each Shot, he put no Wad after the Bullet, becauſe the Piece was mounted, he tried the ſtrength of his Powder, and noted it down, to compare with other Powder, to know its ſtrength by; and that is the way all Gunners muſt take, that intend to make good Shots at Random. Note alſo that all Gunners ſhould be able to draw an exact Deſcription of any Garriſon, and every object that lieth near his Works (by the Rules of the ſeventh Chapter of the Art of Surveying by the Sea-Compaſs in this fifth Book;) ſo that he may know what is within reach of his Guns, by which means he ſhall be ready at all times to know his Diſtances by his Maps: Then after he hath made one Shot, he may make another Shot to any Diſtance he pleaſeth.

Example.

Suppoſe I know the diſtance by my Map where the firſt Shot grazed to be 704 Paces, the mounture of the Piece being 4 degrees, how much muſt I mount the Piece to convey her Shot 900 Paces.

You muſt proportion theſe diſtances of Random, to thoſe in the Table following: ſaying, if 704 Paces require 370 Paces, (as is in the Table at 4 degrees of Random) what number will anſwer unto 900?

Work thus.

Extend the Compaſſes from 704 to 370, the ſame will reach from 900 to 473.

$$\frac{370 \times 900}{704} = 473$$

Or thus.

The Logarithm of the Shot made 704 is —— ——	284757
The Log. of the numb. in the Table againſt 4 deg. *viz.* is 370 —	256820
The Logarithm of 900 Paces Random is —— ——	295424
The Sum is ——	552244
	267487

Gives the Logarithm of 473 Paces, which I look for in the Table of Randoms, but find no ſuch number there, but the next leſs is 461, againſt 6 degrees. and the next greateſt is 550 againſt 7 degrees, the difference between theſe two Numbers is 44, and 461 is 12 leſs than 473, and 12 is near one fourth part of 44, and therefore it ſhews that the Piece muſt be mounted at 6 degr. $\frac{1}{4}$ to reach the Diſtance of 900 Paces.

This

This is the Table of Randoms that was made out of the forenamed Saker of eight Foot long, and loaded with three Pound of Powder, and every Gunner is adviſed, if poſſible, to get Powder to make one by his own experience, and always to keep ſome of the ſame Powder to try any other Powder he ſhall have occaſion to uſe, for this is one of the material things belonging to a Gunner, without which he can never make a good Shot, for at the time of a Leagure he muſt expect often to change his Powder, and ſometimes ſhall have 9 pound of one ſort as good as 15 of another ſort, as by ſhooting you may experience.

A Table of the proportion of dead Ranges.

Deg.	Randoms.
0	206
1	225
2	274
3	323
4	370
5	416
6	461
7	505
8	548
9	589
10	630

SECT. XXXIV.

How to make the Gunner's Rule, being an Inſtrument which will elevate a Piece of Ordnance with more facility than the Gunner's Quadrant.

BEcauſe the Quadrant on the back-ſide of the *Scale* cannot be conveniently uſed at all times, eſpecially when being near the Enemies Guns, and the wind blows hard, the Plumb-Line is too long before he ſtands ſtill; to remedy this, the Gunners Rule was invented; the Figure thereof you may ſee here; this Ruler muſt be 10, 12, or 14 Inches long or more according as the Gun will require it, and muſt have a long ſlit down the middle thereof, the Head thereof make Circular according to your Gun, as you ſee in the Figure; the Inſtrument is deſcribed ſtanding upon his Britch of a Piece of Ordnance; in the middle of the ſmall narrow ſlit you muſt place a Lute-ſtring, or a well twiſted Silk-ſtring with a Bead on it; this Bead muſt be ſet to Inches and parts, as you find is agreeable to ſuch a degree as you muſt mount your Gun to, on one ſide the ſlit there being placed a Diviſion of Inches, and every inch into 10 parts, and thus it will ſerve for all ſorts of Guns; but if it be for a particular Gun, then on the other ſide you may place the degrees and minutes when you ſhall find it by the length of your Gun, how many Inches and parts correſpond thereto; but to uſe it with all ſorts of Ordnance, let it only be divided into Inches and Parts.



SECT.

SECT. XXXV.

How to divide the Gunner's Rule into degrees by help of a Table, fitting it for any Piece from five foot long to 14 foot long; and by the help of this Table, any Piece may be Elevated to any degree without the help of a Quadrant, Ruler, or any other Geometrical Instrument whatsoever.

NOte, this Table hath 11 Columns, the first shews the length of the Piece in Feet and half Feet, the other shews the Correspondent length from 1 degree to 10d egrees in Inches and 100 Parts.

If your Gun be 8 Foot long one Inch $\frac{41}{189}$ makes one degree; your Gun 12 Foot long five Inches $\frac{2}{100}$ makes 2 degrees. Or you may set your Bead to 5 $\frac{8}{100}$ Inch, to mount him 2 degrees.

The length of the Piece	1 Degree		2 Degrees		3 Degrees		4 Degrees		5 Degrees		6 Degrees		7 Degrees		8 Degrees		9 Degrees		10 Degr.	
Feet and ½ Feet.	*Inch.*	100	*Inch.*	100	*Inch.*	100	*Inch.*	100	*Inch.*	100	*Inch.*	100	*Inch.*	100	*Inch.*	100	*Inch.*	100	*Inch.*	100
5 Foot long.	1	5	2	63		84		115		146		197		13		829		2510		28
5 Foot and half.	1	14	2	28	3	424		565		706		847		98		1210		2611		40
6 Foot long.	1	22	2	443		664		886		107		383		59		78 11		812		29
6 Foot and half.	1	46	2	724		85		446		803		179		53		8912		2513		68
7 Foot long.	1	32	2	944		415		887		358		8210		30		7713		2414		78
7 Foot and half.	5	583		144		716		287		859		42 10		99		5512		1415		71
8 Foot leng.	1	683		365		46		728		4010		811		76		4415		1216		82
8 Foot and half.	1	793		585		377		168		9510		7412		53		3216		1217		92
9 Foot long.	1	893		795		387		588		4711		3713		27		1817		818		98
9 Foot and half.	2	004		05		08		010		011		1014		2		316		420		4
10 Foot long.	2	104		205		308		4010		3012		6114		73		8418		5621		8
10 Foot and half.	2	214		415		698		8811		8112		3815		48		6819		8922		10
11 Foot long.	2	314		626		939		2411		5013		8816		22		5120		8223		14
11 Foot and half.	2	424		487		269		6812		1014		5316		95		3721		8024		21
12 Foot long.	2	535		67		5910		1212		6515		1817		71		2522		7825		33
12 Foot and half.	2	635		207		8910		5213		1515		7818		41		4223		6526		33
13 Foot long.	2	745		488		8210		9613		7016		4419		48		9224		6227		40
13 Foot and half.	2	845		688		5211		3614		2017		119		88		7225		5628		42
14 Foot long.	2	955		908		8511		8014		7517		7020		65		6023		5629		53

SECT. XXXVI.

How to give Level to a Piece of Ordnance with the Gunners Rule at any Degree of Random.

YOur Piece being Loaded in all points as is before taught, and you having brought the Piece in a Right-line with the Mark, the Diſpert being placed upon the Muzzle-Ring; in like manner place your Ruler upon the Baſe-Ring, holding it upright, which you try with a Plum-line fixed thereto. Now having before the Diſtance to the Mark you intend to ſhoot at, admit it be 461 Paces, and the firſt ſhot you made for practice out of that Gun, conveyed her ſhot at two degrees of mounture 274 Paces, then according to the Tables of Random, in Section 33, I find 461 againſt 6 degrees, to which I muſt mount the Gun to reach the Mark.

Then to find by this Table how many Inches, and hundred parts of one Inch 6 degrees will require; look in the Table above, and find on the left hand in the firſt Column the length of the Piece, ſuppoſe 13 foot, under 6 degrees in the common-Angle, you ſhall find 16 $\frac{44}{100}$ Inches, and to that height I ſet the Bead on the Lute-ſtring; then cauſe the Piece to be mounted higher or lower, until you bring the Bead, the top of the Diſpert, and the Mark all in one Line, ſtop the Piece in that poſition with a Coyn, then Prime, and give Fire.

If you will ſhoot by the Metal of the Piece, ſubtract the height of the Diſpert out of the Inches found by the Table, and the remainder mount your Piece unto; if the Diſpert be 3 inches $\frac{1}{4}$ long, ſubtracted from 16: 44 found in the Table, leaves 12 $\frac{12}{100}$, or 12 $\frac{1}{10}$ of an Inch, which is the height of the Bead to ſhoot the ſame diſtance by the Muzzle-Ring without the Diſpert.

SECT. XXXVII.

How by the Table to Level a Piece of Ordnance, without the Gunners Rule.

IF you have not a Quadrant, nor a Rule, and would make a ſhot at 4 degrees of Elevation, look in the Table, and find the length of the Piece, which ſuppoſe to be 9 foot and half, right againſt 9 $\frac{1}{2}$ in the Angle under 4 degrees, you ſhall have 7 Inches to be the length of any Stick, cut, and ſet it upon the Baſe-Ring, and and bring the top of the ſaid Stick, the top of the Diſpert, and the Mark in a Right-line with your Eye, and Prime, and give fire, and you may make a good Shot; and if you will have no Diſpert, take the Diſpert, and meaſure it upon the foreſaid Stick at the Baſe-Ring, and from it cut off its length, and the Remainer you may uſe upon the Baſe-Ring, and it ſhall mount the Gun to 4 degrees, as before; and bring the top of the Stick, the Muzzle-ring, and the Mark in a Right-line, and you may make a goot ſhot; if the Diſpert were 3 inches, that cut from 7 inches, the Remain is 4 inches, for the length of the Stick to be ſet on the Baſe-Ring, for to level the Piece without a Diſpert.

Sect. XXXVIII.

How to make a Shot at the Enemies Lights in a dark Night.

UPon ſuch occaſion, to ſhoot at a Light ſeen in the Night, Diſpert your Piece with a lighted Wax Candle, or with a lighted piece of Match, that with your Eye you may bring the Baſe-ring, the fired Match on the Muzzle-Ring, and the Enemies Light in a Right-line, (or mark) then give fire, and you may make a good ſhot.

Sect. XXXIX.

How to make a perfect Shot at a Company of Horſemen, or Footmen paſſing by the place where Ordnance doth lie upon a Level-ground; and alſo to make a good Shot at a Ship Sailing upon a River.

TAke a Piece that will reach the way or Mark in a Right-line that the Horſe or Foot are to paſs by, then your Gun loaded ſo with Powder that it may preſently take fire, and taking a Tree, Buſh, or Hillock, or ſome croſs way for his Mark, and when the Enemy come near to that way in a Right-Line with his Gun, give fire: And ſhooting at a Ship in a River, he muſt put his Piece to ſome evident Mark on the other ſide the River, and when the Head of the Ship ſhall begin to be betwixt the Piece and the Mark, and then give fire.

Sect. XL.

How to cauſe the ſame quantity both of Powder and Shot, diſcharged out of the ſame Piece, to carry cloſe, or more ſcattering.

IN the Book of Mr. *John Bate* of *Extravagants*, he ſaith, take the quantity of a Peaſe of *Opium*, and charge it among the Caſe-ſhot, and it will make the ſaid ſhot flie cloſer together than otherwiſe it would; for *Opium* is of congealing and fixative nature; this a Seaman found by experience.

Sect. XLI.

How a Shot which ſticketh faſt within the Concavity of a Piece, that it cannot be driven home unto the Powder, may be ſhot out without hurt to the Gunner, or to the Piece.

WHen any Piece of Ordnance is charged with ſuch a ſhot that will not be driven home unto the Powder, then the Gunner to ſave his Piece from breaking, muſt ſo imbaſe the mouth thereof, that fair Water for two or three days being put into the Touch-hole at ſeveral times, may run into a Veſſel ſet under the mouth of the Gun, to ſave all the Saltpeter that was in the Powder: And then let the Gunner clear the Touch-hole, and put in as much Powder as poſſibly he can, and Prime, and give fire, and it will ſerve to drive out the ſhot.

But when a Shot hath lain long in a Piece, until it is grown ruſty, and ſo ſticks faſt; put ſtrong Vinegar into the mouth of the Piece, and with the Rammer ſtrike the Shot until it doth move, then put in Vinegar until it run clear through the Powder and Shot, Prime, as before, and give Fire with good Powder; and if it do not run through after it hath ſtood three days, clear the Touch-hole, Prime, and give fire.

Sect.

SECT. XLII.

A Piece of Ordnance at the ſame Elevation, and towards the ſelf-ſame place, with the like quantity of Powder and Shot, diſcharged ſeveral times, what difference there is in their Ranges.

THere hath been a Piece diſcharged in the ſpace of an Hour ſeven times, with the like quantity of Powder, Shot, and Mounture, and their Ranges have been found as followeth; the firſt ſhot was conveyed 418 Paces, the ſecond 438, the third 442, the fourth 434, the fifth 427, the ſixth 412, the ſeventh 395, ſo that the greateſt difference from the firſt ſhot was 24 Paces; this every Gunner muſt take notice of, if he intends to ſhoot well at Random; the reaſon of theſe things is this, the firſt ſhot of Powder found, the Chamber of the Gun moiſt, and the Air quiet, the ſecond ſhot, the Chamber was dried, and the Gun in a good temper, and the Air moved towards the Mark with the firſt Bullet, and having leſs reſiſtance than the firſt, went beyond, and made the beſt ſhot; and every ſhot after come ſhorter and ſhorter, as the Gun grows hotter and hotter; the reaſon is, by how much hotter the Piece is, by ſo much the more attractive is the cavity of the Piece made; and becauſe the ſhot is driven forth or expelled with no other thing, than by the Airs exaltation, or Wind, cauſed by the Saltpeter, therefore the oftner the Piece is fired, and the more hot, the more attractive ſhe is which ſucketh and retaineth continually more of that Wind, which ſhould ſerve to expel the Bullet; and therefore the virtue expulſive in that Piece, doth more and more decreaſe, and the ſhot flyeth not with that ſwiftneſs as it did before in the two firſt ſhots, which dried and brought the Gun into his beſt temper; but the third and fourth ſhot is but little difference from the firſt, but the reſt differ every ſhot.

Nicolas Tartaglia doth report, that many ſhots being made at a Battery by a Piece, it chanced by ſome occaſion, the Piece roſe up in ſuch ſort that it touched the ground with its Muzzle, a little Dog running by did ſmell into the Mouth of the Piece, and after a little time was drawn almoſt to the further end of the concavity: They pulled him out almoſt dead; this was done by the attraction of the Piece.

SECT. XLIII.

How to Weigh Ships ſunk, or Ordnance under Water: Or to know what empty Cask will carry any ſort of Ordnance over a River.

NIcolas *Tartaglia* hath well collected from the Learned *Archimedes*, and hath calculated the Proportion of Stone, and other Metals, what they will weigh in the Water, and in the Air.

All Men know by reaſon, that whatſoever is heavier than ſo much Water, as the body of the Metal thruſteth out of the place, or Veſſel, will ſink; and being lighter than ſo much Water, will ſwim.

Tartaglia ſaith, that ordinary Free ſtone weighing 93 pound in the Air, will weigh but 48 in the Water, which is near as 2 is to 1, between the Free-ſtone, and the Water. And that Marble-ſtone that weigheth 7 *l.* in the Air, will weigh but 5 *l.* in the Water, which is near as 7 to 2, between the Marble and the Water.

And Iron and Tin, that in the Air weigheth 19 *l.* will weigh 16 *l.* in the Water; ſo it is as 19 to 3.

Braſs weighing in the Air 65 *l.* will in the Water weigh 55 *l.* and ſo Braſs is to Water, as 65 to 55.

And Lead weighing in the Air 30 *l.* will weigh in the Water but 27 *l.* ſo Lead is to Water, as 30 to 27.

And laſtly, Gold in the Air being 17 *l.* in the water it will weigh but 16 *l.* ſo Gold is to Water, as 17 to 1. He alſo layeth down Rules to weigh Ships, or Guns, or any thing elſe in the Water, that hath not lain too long, and docked it ſelf in Ouze: for if the thing ſunk be upon Sands or Rocks, it will weigh the better. He deſcribes Veſſels Loaden to be brought to the place where the thing ſunk, and a Globe of Glaſs put in a Frame of Wood, and a place in the bottom of the Glaſs to put in ones head into the concave, he may both ſee and breath, and by a Windleſs Rope, and weight to ſink it, he may firſt let down the weight, and after heave himſelf down in that Frame, (it is in the form of an Hour-glaſs) to the bottom, and ſo ſling the Ship, and Guns, and when he will come up to the top again, unwind the Rope, and the Frame will be guided upright, and he and it will come to the top of the water very ſafe, and faſten this Rope brought from the Ships to loaden Veſſels, and then unlead the Veſſels, and they will buoy up the Ship ſunk, or any other thing from the ground.

Briſtol, Sept. 12. 1667. *by experience of a Spaniſh Ship called the* Victory *of* Majork, *ſunk in* Kingrode *at the* Pill; *her Burthen about* 300 *Tuns; we weighed her with* 4 *empty Lighters, of* 30 *Tuns a piece, by laſhing the Lighters at Low-water, Head and Stern; and at High-water we heav'd the Ship on ſhore by a Grapple, the Ship did riſe as the Water did flow; and the Low water or two afterward, the Ship was free, and ſwom; the Ship and Water was Eſtimated to weigh* 1000 *Tuns, that the four Lighters weighed; ſhe had no Goods in, but turned over as ſhe was upon the Carein.*

Or it may be done thus by a Float-Stage, and Capſton, with a Trunk of Leather made ſo thick that no water can come in, and with a pair of Glaſs Eyes faſtened that no water can go through, fitted to the Caſe of Leather within, and two Bladders blown at the brim or top of the Water, made faſt to the Pipe of Leather to buoy the mouth of the Pipe, while the Man goes down with Ropes fit to ſling, and make them faſt at liberty; then hale him up after a fit time, and by your Veſſels, as before, and Float-Stage, heave and buoy up the thing ſunk.

The beſt weighing of Ships is where the water ebbs and flows much.

Know this, that five Tun of Cask will ſwim a Canon of 8 or 9000 weight, 4 Tun a Demi-Canon, 3 Tun a Culverin, and 2 Tun a Saker, with all things belonging thereunto, as Planks and Ropes.

Sect. XLIV.

How many Horſes, Oxen, or Men will ſerve to draw a Piece of Ordnance.

For every hundred weight of Metal, one Man; ſo a Piece of 8000 Pound weight requires 80 Men, and as many more Men as the Carriage may weigh, for every 500 weight of Metal, one Horſe, then 16 Horſes will draw a Gun of 8000 weight; but in the Winter 24; alſo 17 Yoke of Oxen is thought ſufficient to draw a Piece of 8000 weight, but in the winter, they had need to be one third part more.

OF ARTIFICIAL FIRE-WORKS, FOR Recreation, AND SEA and LAND-SERVICE.

CHAP. XII.

SECT. I.

A Deſcription of the Mortar-Piece, and how to make one of Wood, and Paſt-board (for a need,) Braſs and Iron once being wanting.

THe ſame Metal that makes the beſt ſort of *Braſs-Ordnance*, they make Mortar-Pieces with, and by theſe Meaſures; if the Diameter or Bore be 9 Inches, let the Mortar be one foot and half in length, and let the Chamber, in which you load your Powder be three Inches Diameter, and four and a half deep; the thickeſt of the Metal above the Touch-hole three Inches, and the upper part thereof an Inch and a half.

To make the Mortar-Piece of Wood and Paſt-Board.

Provide a Wooden-Rouler of ſuch bigneſs as you deſire to make the Diameter of the Morter, then greaſe your Rouler well, that the ſtuff may ſlip off that is put about it, which is Paſt-board and Canvas, and very well plied with hot Glue; and after let it dry a little while on the Rouler, and another while off from the Rouler; and when this kind of Trunk is very dry, put it on the Rouler, and ſet it in a Lathe, and cut off both ends of the Trunk with a Chizel very even, then turn a Foot thereto with a ſhoulder to put the Trunk upon, and in the middle thereof make the Chamber for your Powder; if the Piece be 8 Inches in the Mouth, let the thickneſs of the Paſt-Board-Trunk be 2 Inches thick, and 18 Inches long, the Britch or Foot 10, the ſhoulder 2 Inches long, and 2 high, that when the Trunk is put on this ſhoulder, and joyned with the Wood, it may be juſt even with the ſame; the Bore into which you put your Powder muſt be two Inches high, and three deep, Plated with Cop-

per,

per, Lattin, (if it be poſſible) as alſo all the reſt of the Wood that goeth into the Trunk; when you have put the Trunk into the Britch of Wood, nail it round about the ſhoulder, making holes for the Nails, and then driving in the Nails upon that Wood, that you made to receive the Paſt-boards or Trunk; then cover both Wood and Trunk with good Belch-Cord and Glue again, and let it be well dried, it will laſt a long time; and with ſuch you may ſhoot Ballouns into the Air for Recreation.

Sect. II.

How to fit and prepare Granadoes for the Mortar-Piece.

The Shot of great Mortar-Pieces are moſt commonly one tenth part lower than the Bore, becauſe of Cording them, to fling into the Mouth of the Piece; and for fear of ſecret Cracks, which cannot be eaſily eſpied, they are coated with Pitch, ſo that being fitted and prepared, they do but juſt fit the Bore.

How to make Fuſes.

Every Granado Shell hath an hole left to put in a Fuſe, or piece of Wood, juſt like a Faucet, this hole muſt be juſt one quarter of the Diameter of the wooden Fuſe, which Fuſe muſt be in length three quarters of the height of the Granado; make it taper, and then fill it with compoſition. and drive it gently into the Powder that is in the Shell, leaving a ſittle of it without: The Compoſition of this Fuſe is made thus; take one pound of Powder, four Ounces of Saltpeter, and one of Brimſtone, firſt beaten to Powder, and ſifted in a Sieve ſeverally, theſe Ingredients being mixt together, your Compoſition is fit for uſe.

Sect. III.

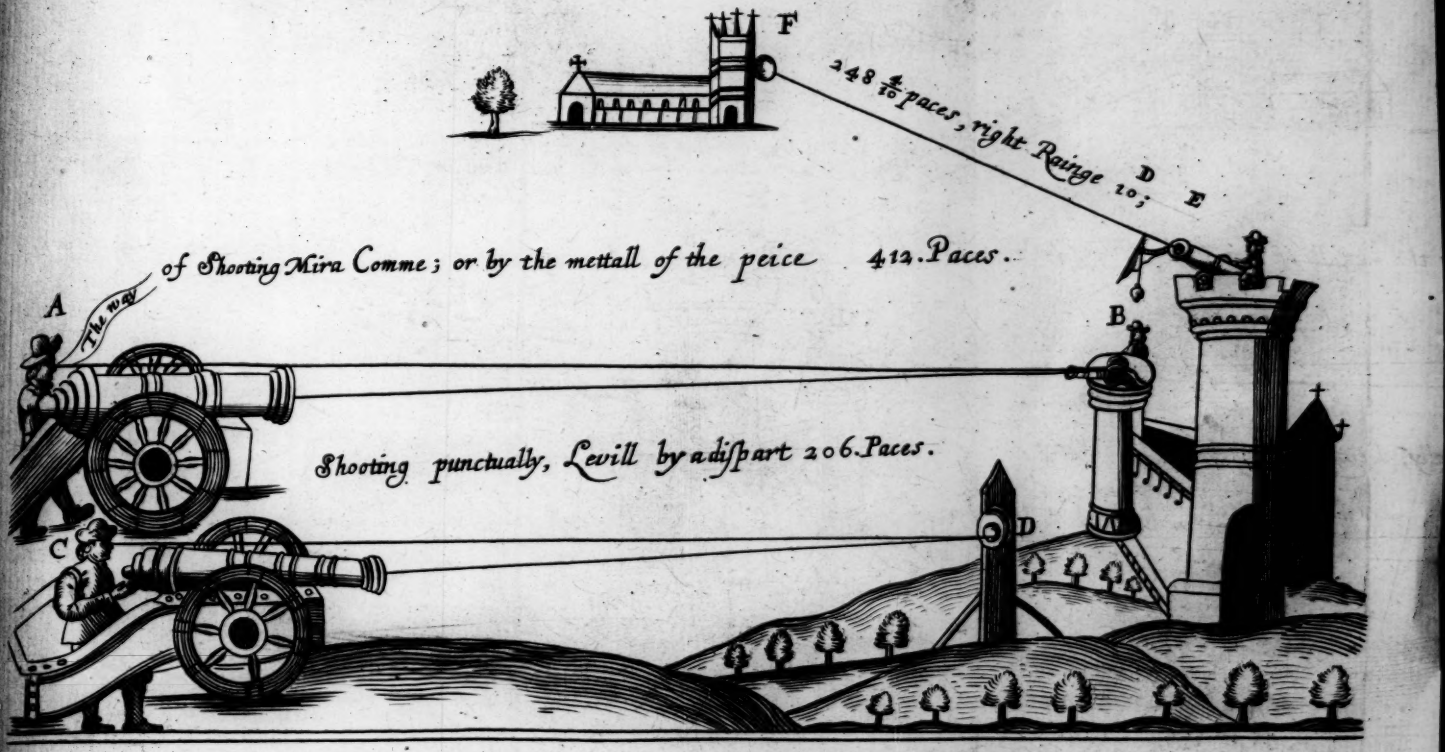
How to make Granadoes of Canvas for the Mortar.

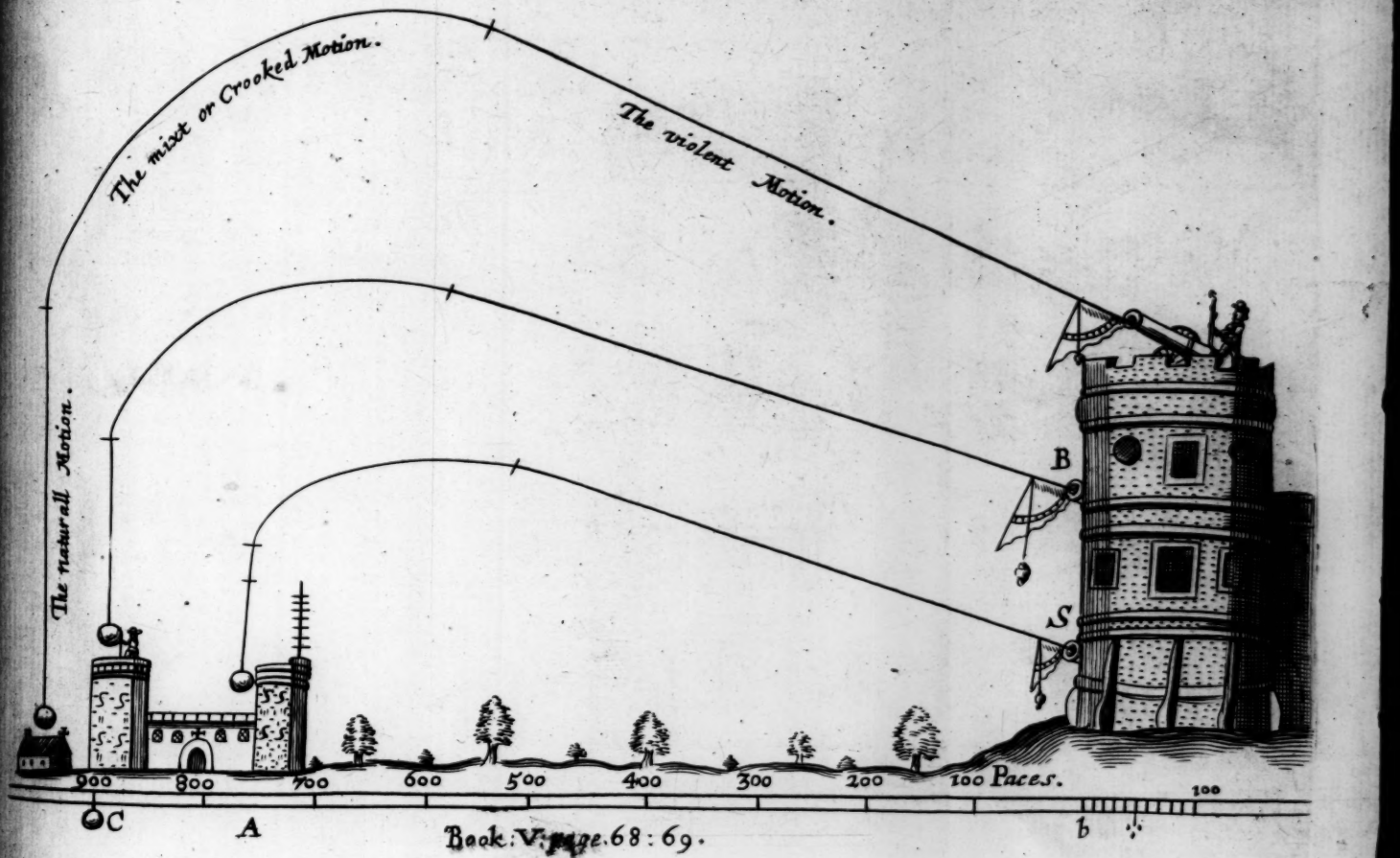
The operation of theſe Granadoes made of Canvas is quite contrary to theſe already ſet down: theſe are only fit to fire a Town, they are not of ſo violent execution as the precedent, yet altogether as coſtly in the making; for the making of them, fit a piece of Canvas upon a round Ball of Wood or Form, ſo big as you would have your Granado, then take this Compoſition following; four pound of Saltpeter, two pound of Gun-powder duſt, and two pound of Brimſtone; all theſe incorporated, and moiſtned with Oyl of Saltpeter; fill your Caſe with this Compound, and cover it with Cords, and pierce the Sack full of holes, and in every hole put an Iron Barrel, charged like a Piſtol; theſe muſt be driven into the Sack unto the head, then let there be an hole about an Inch deep, which ſhall ſerve to prime it with Powder-duſt, moiſtened with Oyl of Petrol; be ſure your Barrels have great Touch-holes, that the Ruſt through time may not choak them, and they will be ready for ſervice many years.

Sect. IV.

How Granadoes are to be charged in a Mortar, and fired.

You muſt take great care in the Loading or Charging the Mortar, thus; firſt, weigh the Powder to a Drachm that you put into the Chamber, and after it put a good cloſe Wadd of Hay, or a Tampion of Wood, then cut a Turf off the the ground that may juſt fill the bottom of the hole or bore of the Mortar next the Wadd; your Granado being prepared, with a coat of Pitch and Cord, as before taught,





Book. V. page. 68: 69.

taught, ſling it into the Mouth of the Mortar; obſerve to have the Fuſe of the Granado in the middle of the Bore, then go to the Britch, thruſt up a Wire in the Touch-hole to make ſure, then Prime with the beſt dry Powder you have; for (believe me) this is a tickliſh ſort of ſhooting; without care, your Life, and Mortar-Piece is now at ſtake; but we will give you very ſure directions how to give fire.

Provide ſmall Fuſes, ſuch as we taught you to make before for Shells, but leſs, about a quarter of an Inch bore, three quarters of a Inch thickneſs, and eight Inches long, fill theſe with good Powder-duſt, moiſten it with Oyl of Peter but a little, and put it in with an Iron Rammer, try whether you like the time, they continue burning; if too ſlow, abate Oyl of Peter; if too faſt, add more to it.

Thus being prepared, the uſe is, (*viz.*) thruſt the Pick of your Linſtock in at one end of the Fuſe you mean to give Fire withal, bid one of your aſſiſtants come to one ſide of the Mouth of the Piece, and give fire to your Fuſe, wherewith fire the Fuſe in the Mortar, and then with great ſpeed give fire to the Touch-hole; theſe Fuſes are very certain to give fire, but Match doth oftimes fail.

SECT. V.

How to make Hand Granadoes to be hove by hand.

THere is good uſe made of Hand-Granadoes in aſſaults, and Boarding of Ships, and there be two ſorts of them made; the firſt is ſhewed already, the ſecond is made by Sea-Gunners upon a Mould made with Twine, and covered over with Cartrage-Paper, and Muſquet Bullets cut in two, put with Paſte and bits of Paper thick on the out-ſide; after you have doubled the Shells, Paſte on ſome at a time, and let it dry, and then ſome more, until it is quite full; then dip it in ſcalding Rozin, or Pitch, and hang it up, and it is for your uſe; but you muſt have the innermoſt end of the Twine left out at the ſmall hole for the Fuſe; and before you Pitch it, you are to wind it out, and ſtop the hole, and then Pitch it.

The Shells are made of Glaſs, or neal'd Clay, or Paper.

To Load them, fill theſe ſmall Shels with Gun-Powder, then make a Fuſe of one Pound of Gun-Powder, ſix Ounces of Salt-Peter, and one of Charcoal; or if you will have them of leſs durance, you may take the Compoſition made for the Fuſes before ſpoken of for great Granadoes, knock the Fuſe up to the head within one quarter of an Inch, which is only to find it by in the night; ſtop well the reſt of the holes, if any Chinks are open, with ſoft Wax; then your firſt Shells muſt be coated with Pitch and Hurds, leſt it ſhould break with the fall; and be ſure when you have fired the Fuſe, ſuddenly to caſt it out of your hand, and it will do good execution.

SECT. VI.

How to make Firy-Arrows or Darts like Death Arrow-Heads.

MAke your Head of Iron, ſharp and bearded, to ſtick faſt and to it have an Arrow or long ſhaft of Wood, and about the middle of that Head make faſt a Linnen Bag in form of an Egg, leaving open at the end a hole, that it may be filled with the Compoſition following; take one pound of Peter, half a Pound of Gunpowder, and as much Brimſtone in Powder; all theſe ingredients being mixt well, and mingled with Oyl of Petriol; with this fill the Bag round about the Arrow-head, then let all be bound about with Wire; and for Priming of theſe, dip Cotton week into Gunpowder wet with water; and well dried again before it is uſed, and let the Arrows or ſhafts be ſo put into the Head, that when they be ſtuck in a Houſe or Ship-ſide, or any where elſe, the man which endeavours to pull them out may be deceived, and pull only the Shaft, and leave the Head to burn the Houſe, or Ship, or

Mens

Mens Cloaths, or any thing elſe; if you throw or ſhoot it well, it will fire whatſoever combuſtible ſtuff or matter ſhall be near it, as Sails, Timber, Pitch, Tarred places; and this will much annoy Enemies in ſtorming a Work, or boarding a Ship.

Sect. VII.

How to make Fire-pots of Clay.

FIre-Pots, and Balls to throw out of Mens hands, or with a *Baſcula*, may be made of Potters Clay, with Ears, to it hang lighted Matches, and throwing them, if it lighteth on a hard thing, it breaks, and the Matches fire the Powder, and the half Bullets of Muſquets contrived upon them, as before, diſperſes, and doth much miſchief; their mixture is of Powder, Peter, Sulphur, and Sal-armoniack of each one Pound, and four Ounces of Camphire pounded, and ſearced, and mixed well together with hot Pitch, Linſeed-Oyl, or Oyl of Peter; prove it firſt by burning it, if it be too ſlow, add more Powder, and if it be too quick, more Oyl, or Rozin, and then it is for your uſe.

Sect. VIII.

How to make Powder-Cheſts.

YOu muſt make them with two boards to be nailed together, like the ridge of a Houſe, and one longer and broader to the bottom thereof; between the three Boards put a Cartrage, then make it up like a Sea-Cheſt, and fill it with Pibble-ſtones, Nails, Stubs of old Iron; then nail the Cover on, and the end to the Decks in ſuch a place as you may fire the Powder underneath through a hole made to put a Piſtol in.

Sect. IX.

How to make Artificial Fire-Works for Recreation and Delight.

WE ſhall not deſcribe the Moulds in particular, being needleſs; for ſuch Men as are inquiſitive into theſe things, let them buy Mr. *Babrington*, or *Bates*, or *Malthus*, or *Norton*'s Fire-Works; here we will lay down ſuch Rules, as ſhall be as ſoon conceived without Figures, only a Rouler or Mould for to make the Paper upon and that may ſerve for all the reſt, they being made in the ſame manner.

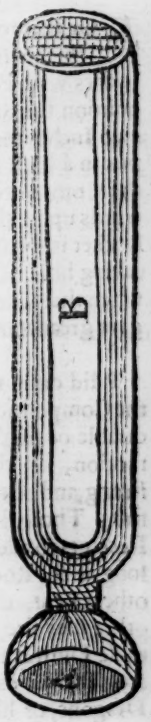
To make good experienced Rockets our way, do thus; get a Form or Rouler to be turned in a Lathe, what thickneſs you pleaſe, and intend to make your Rockets, and let his length be 8 times the Diameter; if it be $\frac{1}{4}$ of an Inch in thickneſs, the length will be 6 Inches, put ſo many Rouls of Paper on this Form, until it is half an Inch thicker, or make it $\frac{1}{2}$ Inch the whole, then paſte the upper ſide to the reſt; then you muſt contract the Paper together an Inch from the Mouth, thus: Dip an Inch of the Caſe in water, the Formor in him, and with Twine, about $\frac{1}{4}$ of an Inch from the end gather it in; but let a Formor, or a thing near the bigneſs be put into his Mouth, while you draw it in with the Twine and choak it; you muſt remember to leave a ſmall hole to put in a Wire through the Compoſition half way the Rocket, as big as a Bodkin; then take out the Formor, and dry them, and they are for uſe at any time; the Figure following makes all plain; A is the Mouth of the Rocket, B ſo far the Bodkin muſt be thruſt up the middle; you muſt be provided with a ſmaller Bodkin, which when your Rocket is filled with the Compoſition, and tied to the Rod, you muſt thruſt this Wire Bodkin in at the Mouth, ſtraight up to the midſt of of the Rocket, having a care not to thruſt it more upon one ſide than the other.

Sect.

SECT. X.

To make the Compoſition for Rockets of any ſize,

THe Reader may make uſe of theſe Rules, not upon truſt out of Authors, but found by Practice and Experience; and firſt for Rockets of one ounce; you muſt uſe only Canon-Powder-duſt, being beaten in a Mortar, and finely ſearſed; this makes him riſe very ſwift, making a great noiſe, but carries no Tail. Theſe of more Operations are made by putting one Ounce of Charcole-duſt to eight Ounces of Powder; this Compoſition will hold for Rockets of one, two, and three Ounces; but for theſe of four, take three Ounces of Charcole-duſt to one pound of Canon-Powder-duſt, continuing that Rule, until you come to Rockets of ten Ounces; and alſo for Rockets of a Pound, take one Pound of Powder-duſt, and four Ounces of Charcole-duſt, and theſe are big enough for any recreation or delight.



To fill the Rockets with this Compoſition.

Hold the Mouth downwards where it was Choaked, and with a Knife put in ſo much as you can of the Receipt provided for that ſize at one time, then with a Rammer fitted to the Caſe, and with a Mallet give three or four indifferent knocks, then put in more Compoſition until it be full, every time knocking the Rammer, as before, until the Compoſition come within one Diameter of the top; then put downa piece of Paſteboard, and knock it in hard, prick three or four little holes therein; then put fine Piſtol-Powder in almoſt to the top, and upon that another cap of Paper upon which put a Piece of Leather, that it may be tyed on the top of the Rocket, and faſt glued on; then get a ſtraight Twigg, and bind it upon the Rocket with good Twine; it muſt be no heavier, than being put upon your Finger an Inch and a half from the Mouth of the ſame, that it may juſt ballance the Rocket, then it is prepared for uſe.

To give fire to one or two Rockets.

Set your Rockets Mouth upon the edge of any piece of Timber, that ſtands ſo high from the ground, that the ſtick may ſtand perpendicular from it downwards, or upon a ſide of a Wale or Carriage-wheel, or any dry place whatſoever; then lay a train of Powder that may come under the Mouth thereof; give fire thereto, and you have done; but to fire more Rockets than one, that as one deſcendeth, the other may aſcend by degrees: Make this Compoſition following; of Roch-Peter eight ounces, Quick-Brimſtone four Ounces, and fine Powder-duſt two Ounces, which lay in a Line, from one Rocket to another, they being placed ten Inches, or a Foot one from another; give fire to this Compoſition, and you have your deſire, if you did prick the Rocket with the Wire, as directed; you ſhall ſee how gallant one will mount the Air, when the other is ſpent.

Sect. XI.

How to make flying Serpents and Rockets that will run upon a Line, and return again.

FOr this you muſt provide a ſmall Rowling-Pin about one quarter of an Inch in thickneſs; upon which roul ſeven or eight thickneſs of Paper; fill them four Inches with Powder-duſt, ſometimes putting between the filling a little of the Compoſition for Rockets of ten Ounces, and at the end of four Inches choak him; fill two Inches more with Piſtol-Powder, then choak the end up, and at the other end put in a little of the mixture for Stars, which follows, and choak between them and the Compoſition, and it is fit for uſe; but divers of thoſe with the Starry end downwards upon the head of a Rocket and Powder-train to blow them out, when the Rocket is ſpent, they will firſt appear like ſo many Stars; when the Stars are ſpent, taking hold of the Powder-duſt, they will run rigling to and fro like Serpents, and when that Compoſition is ſpent, they will end with every one a report, which will give great content to the beholder.

I did omit to ſpeak of Runners in its proper place in the laſt Section, for that is the Compoſition, which you muſt make them of, very carefully whether they be double or ſingle, or thoſe that carry Dragoons, Men, or Ships, or other Shapes in motion, leſt they ſhame their Maſter; the Line muſt therefore be fine, even, and ſtrong, and being rubbed over with ſoft Sope to make it ſlippery, and not eaſily to take fire; Thoſe that turn Wheels, may have a further addition of Roch-Peter in their Receipts to add pleaſure and life to the beholders; You muſt have a piece of Cane as long as the Rocket, and bind to the Rockets, and ſo that ones Head may be to the others Vent, that when one hath carried the Cane on the Line to the end thereof, the other may fire, and bring him back again to the Tower or place where it was fired; theſe Figures are made with ſtrong Paper or Parchment, and with Lattin, and Wire, and Twine, until they be brought into theſe Shapes, and then painted like Ships, or Dragons, or like the thing it carries with it.

Sect. XII.

How to make Fire-Wheels, or as ſome call them Girondles.

FIrſt be provided with Spinning-Wheels, or the like, made eaſie to run round upon its Axis, Horizontal, or Vertically; and put Flaggs on the top of the middle, to ſet out the Wheel; bind Rockets to the Wheel, and Crackers betwixt each Rocket, with the Mouth of one towards the Tail of the other; thus continued, until you have fitted the Wheel quite round; which done, cover them with Paper paſted over, and coloured handſomly to ſet it out, that one taking fire, they may not fire all, and daub Soap upon them quite round, leaving the mouth of one of them open, to give fire thereto; the firſt Rocket being burned will ſet fire to the reſt one after another, keeping the Wheel in a continual motion, until they be all ſpent; you may bind Fire-Lances to theſe Wheels, either upright, or near over athwart, which will make to appear diverſity of Fire-Circles; you muſt take care to place your Wheels called *Girondles* at convenient diſtance from other Fire-Works, leſt they ſhould make a confuſion, and ſpoil all the Work.

SECT. XIII.

How to make divers Compoſitions for Stars.

FOr Stars of a blue colour mixed with red the Compoſition is of Powder-mealed eight Ounces, Salt-Peter four, Quick Brimſtone twelve Ounces, meal all theſe very fine, and mix them together with two Ounces of *Aqua Vitæ*, and half an Ounce of Oyl of Spike; which let it be very dry before you uſe it.

Another Compoſition which will make white and beautiful Fire; take Powder eight, Salt-Peter 24, quick Brimſton two, Camphire one Ounce, meal theſe ingredients, and incorporate them; meal the Camphire with dipping your Peſtle into a little Oyl of Almonds, and it will meal preſently, and keep it cloſe from the Air, or elſe it will become of no uſe.

Another White Fire which laſteth long; take Powder four, Salt-Peter ſixteen, Brimſtone eight, Camphire one, Oyl of Peter two Ounces, meal theſe that are to be mealed, and mix them according to the former directions.

SECT. XIV.

How to make and uſe the Stars.

TAke little ſquare pieces of Brown Paper, which fill with either of the foreſaid Compoſitions which you like beſt, fold it down, rowling it till you make it round, about the bigneſs of a Nut or bigger, according to the ſize of your Rocket that you intend them for, Prime them with drawing through them Cotton-Weck, and they are prepared to make faſt to the Wheels: You may alſo make them thus; you muſt have a Rowler which muſt be as big as an ordinary Arrow, which ſhall be to rowl a length of Paper about, and paſte it round, and dry it well, fill it with a Thimble, and thruſt it down with a Rowler, and then cut it in ſhort Pieces about half an Inch long; then you muſt have in readineſs either hot Glue, or Size mingled with red Lead, dip therein one end of your ſhort Pieces, leſt they take fire at both ends together; beſides, it will not ſo eaſily blow out; theſe being thus done, ſet them to dry until you uſe them; in the top of the Rocket, whereas in Section 10 you were to fill it with Piſtol-Powder, now you muſt put but a very little, and that is to blow the Stars out, which muſt ſtand in the room of the Powder, and on the top of that another Tire with ſtrewing a little Powder and duſt; and in like manner another, to a third or fourth, putting a little ſmall corned Powder between them, until you come unto the top of the Rocket-caſe, there put a Paper over the Head of it, and tie it cloſe about the top, that none of the Powder come from between the Stars; the Cotton-Weck is ſuch as the Chandlers uſe doubled ſix or ſeven times, dipped in Salt-Peter Water, or *Aqua Vitæ*, wherein ſome Camphire hath been diſſolved; or for want of either, in fair Water, cut it in divers pieces, rowled in mealed Powder dried in the Sun, and it is done.

SECT. XV.

How to repreſent divers ſorts of Figures in the Air with Rockets.

WHen you have divers Rockets to make for a great Fire-Work, let one be with a Report, another with Stars, another with golden Hair or Rain, one with Silver Hair or Rain, which it ſeems to be when you are right under it; and upon the Head of another Rocket place the Serpents, and they will make moſt delightful ſport.

Sect. XVI.

How to make Silver and Golden Rain, and how to uſe them.

You muſt provide ſtore of Gooſe-Quills, which you muſt cut off ſo far as they are hollow; the Compoſition to fill them is, two Ounces of Coal-duſt, and one Pound of Powder well mixed; having filled many of theſe Quills, you ſhall place them in the ſame place as I told you to put the Powder and Stars, putting a little Piſtol-Powder to blow them out, as you did the Stars, and fill the top of the caſe as full of them as you can, with the open end downwards; ſo ſoon as the Rocket is ſpent, there will appear a Golden Shower, or Rain; or with the Compoſition for White-Stars filled in the Quills, will make a ſhower of Silver Rain.

Sect. XVII.

How to make Fire-Lances.

Make them thus; firſt, you muſt make Cartrages, or Caſes juſt like the Caſes for Rockets, only thoſe for a need may be made with Paſtboard, and glued, as they are formed round, but the former is better; let them be filled with the dry Compoſition for Stars as in Section 13. Prime them with wet Gun-Powder, the lower end of the Caſe is ſtopped with a piece of Wood, to the end they may be nailed and ſtirred when and where they ſhall be uſed, the Wood being about three Fingers breadth out of the Caſe or Cartrage, or as long as you will.

Sect. XVIII.

The manner how to make Balloons for the Mortar-Piece.

You muſt have a Formor or Rouler twice the length of the Diameter, and of the bigneſs, as you will have the inſide of your Balloon, and upon that Formor put ſo many Paſtboards as you ſhall think ſufficient for ſtrength, then paſte or glue them well together, and choak him at the end with a ſtring, leaving a ſmall hole for a Port-fire, which muſt be made juſt like a Rocket, but no holes in it as the Rocket hath, and of ſuch length as is fit: Now to fill the Balloons, place all your Serpents within it together, with Stars, Rockets, and Crackers, leave very little room within the Caſe, or Cartrage; and being filled, put in as much Powder-duſt as you can, that it may run every where through the Chinks between the Serpents, Rockets, and Stars, that they may all fire, and that the ſaid Powder-duſt may break the Balloon; theſe things thus done, choak up the other end cloſe, and charge it in the Mortar, as we have taught you to do the Canvas Granado in the fourth Section, and you may ſhoot it when you pleaſe, and you will make moſt excellent delight to the Spectators, and credit to your ſelf; for this is part of the way of Mr. *Malthus*'s Fire-Works, which were the beſt that ever I practiſed.

section 17.

section 9

Rockets single or doble made to run vpon a line from tower to tower in this section

H

D

B

A

G

G

F

E

M

N

D

C

B

The Ball A is a Granado, coated armed and leaded sect: 4. th

Fire Pots of Clay wch eares and marked is B section. 7.

Balls to fire and stick is D made of Frame stuffe as 7 section

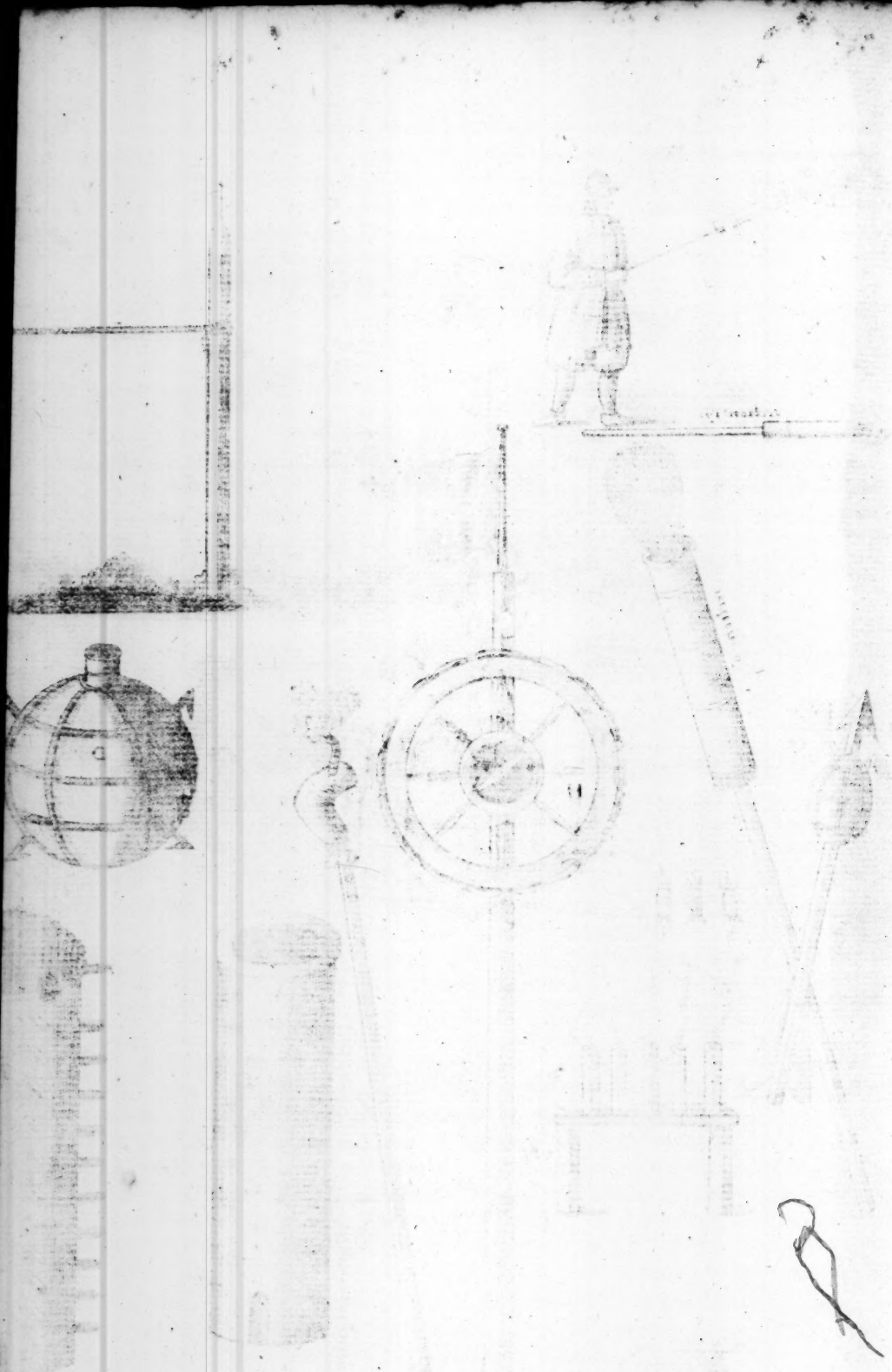
Fire Arrowes or darts sect: 16 is E

FG is a sillinder Granado of turned timber to shoote fliers section the 10.

Vertuall wheele is H sect: 12 by wch you may vnderstand y^e form of horizontall wheeles or any other sort.

ABCD are the mouldpiece mould and Ballons section 18.

And M N is 3 wooden Morters or Chambers as in section 18



SECT. XIX.

A moſt precious Unguent for any Burning.

DIvers men in the practice of Fire-Works one time or other chance to be burned, or blown in the Face by Powder; here you have Mr. *Malthus*'s Salves, which was known by often Experience to be very good, and will fully cure you.

The *SALVES.*

Take freſh Hogs-Greaſe, or Lard, as much as you pleaſe, and boyl, and take off the Scum, until there ariſe no more Scumm; then ſet the Lard three or four nights abroad, after which it muſt be waſhed in running Water to take away the Saltiſh nature, and to make it White; then melt it, and keep it for your uſe.

Otherwiſe.

The White of an Egg, and freſh Butter being mingled together, and well beaten into an Oyntment, is excellent good.

SECT. XX.

Another Salve moſt excellent.

TAke a Stone of Quick Lime, and let it be diſſolved in clear Water, and when the water is ſettled, pour it out gently from the Lime through a Linnen cloth, then put as much Sallet-Oyl as you have Water together, and beat it all to an Oyl; you may keep it for ſuch uſes, and you have a moſt Sovereign Cure for all manner of Burning whatſoever.

The End of the Fifth Book.

TO

TO

Capt. *SAMUEL STURMY*,

THE

AUTHOR,

For his Work and Worth.

SInce 'mongſt all Nations *War* it ſelf doth ſhew,
It Man behooves *Wars* Weapons for to know.
Who here may learn the *Gunner*'s aiming *Arts*,
Which thy free Induſtry to all imparts.
The fitteſt Subject now it is by far,
At theſe Times when ſuch Rumors are of *War*:
And fills the Ears, and courages awake.
Go on then, and to thee this credit take,
That he that Reads theſe things which thou doſt write,
May know a *Gunner*'s part, though he never Fight.
And know *Wars* chiefeſt Engines uſe, and ſtrength,
In *Bar*, *Cylinder*, *Axis*, and in *Length*;
In *Touch-hole*, *Carriage*, *Wadd*, in *Shot* and *Charge*;
Of *Fire-Works*; in brief, Thou giv'ſt in Charge
French, *Spaniſh*, *Dutch*, *Italian*, Vail your Caps
To the Author's skill in *Mars* his Thunder-Claps.

Capt. *JOHN VINCENT.*

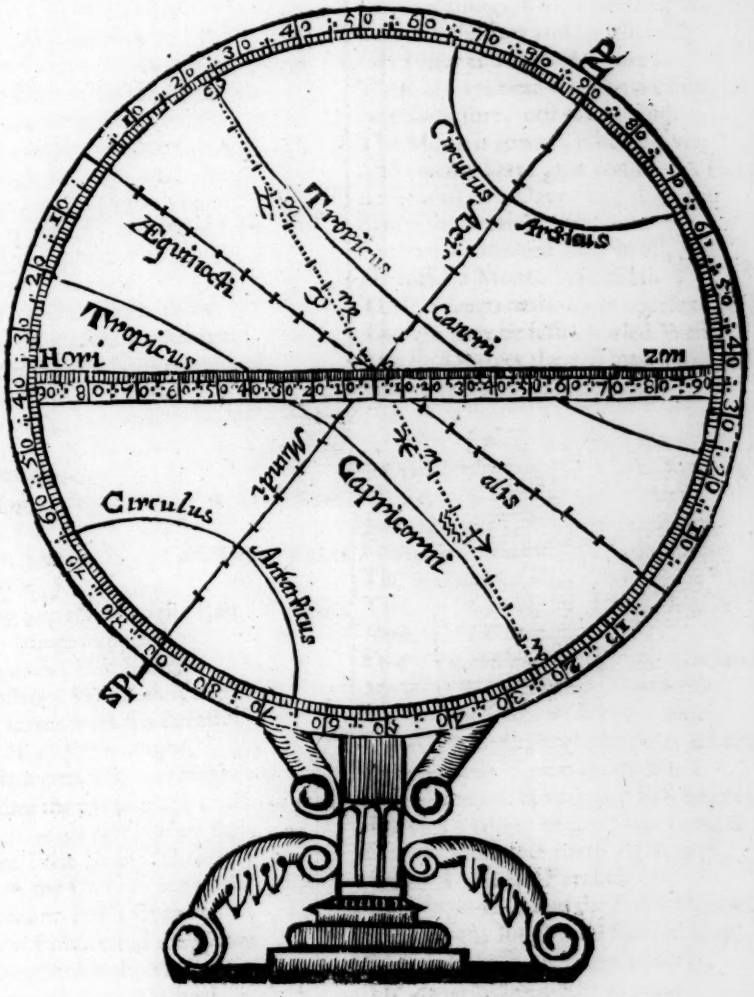
THE

THE MARINER'S MAGAZINE; OR, *STURMY'S* Mathematical and Practical ARTS.

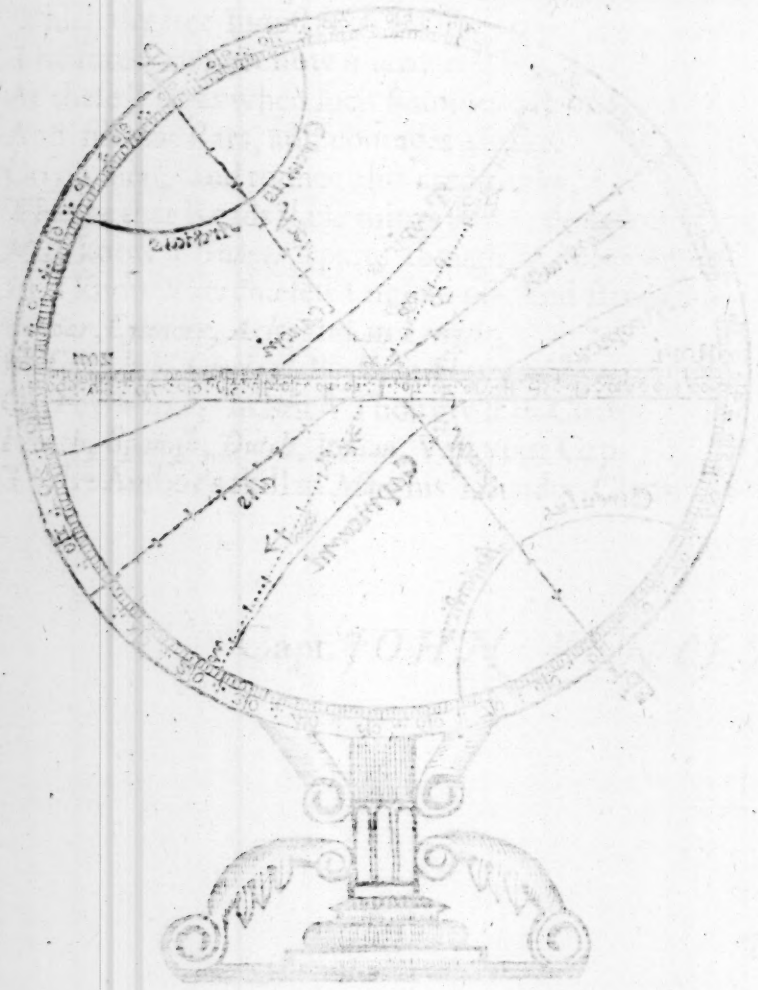
The Sixth BOOK.

Wherein is contained,

The Definitions of the Circles of the Sphere with the manner how to reſolve divers neceſſary Aſtronomical Propoſitions both by Projection, (or the Scale and Compaſſes) and alſo by the Doctrine of Spherical Triangles.



Fælices animæ quibus hæc cognoſcere primum
Inque domos ſuperas ſcandere cura fuit.



Of the Eight and Forty Conſtellations of the Fixed Stars; and of the Circles of the Sphere.

THe Army of the Starry Sky,
Declares the glory of God moſt high,
Seen and perceived of all Nations,
In Eight and Forty Conſtellations.
Firſt, near unto the Northern Pole,
The Dragon and two Bears do role.
Whoſe hinder parts and Tails contain
The leſſer and the greater Wain.
The Hare, the Bear-ward, and the Crown;
And thence comes *Hercules* kneeling down;
And next below a place doth take,
Great *Serpentarius* with his Snake.
Under the Harp of *Orpheus*,
The Eagle, and *Antinous*,
The Silver Swan her wings doth ſpread
Above the Dart and Dolphin's head;
Then *Pegaſus* comes on amain,
Andromeda follows in her Chain;
The Triangle below her ſtands,
And at her Feet in *Perſeus*'s hands
The *Gorgon's* head; above are ſeen,
Her Parents, *Cepheus* with his Queen
Caſſiope, not far below,
Heniochus his Goat doth ſhow
On his left Shoulder, in his hand
He doth the ſtormy Kids command.
Here in the *Zodiack* begins (Twins (♊,)
The Ram (♈,) the Bull (♉,) the loving
The Crab (♋,) the Lion (♌,) and Virgin (♍) tender;
The Ballance (♎,) Scorpio (♏,) and Bowbender (♐,)
Goat (♑,) Water man (♒,) then Fiſhes twain (♓,)
Shall bring you round to the Ram (♈) again.
Fifteen Images appear
In the Southern Hemiſphere,
The monſtrous Whale above the reſt,
Eridanus ſcarce wets his Breaſt.
Over the Hare *Orion* bright,
Sparkles in a cold Winters Night;
Then comes the great Dog, at whoſe Tail
The famous *Argo* ſpreads her Sail:
Above the little Dog doth flame,
For whom the Latines had no Name;
Long *Hydra* on her Tail alow,
Carries the Pitcher and the Crow;
The Centaur holds the Wolf by th' heel;
The Altar, and *Ixion*'s Wheel,
Are never ſeen of us; but here
The Southern Fiſh brings up the rear.

The *Planets*.

Under thoſe fixed *Stars* above,
Seven *Planets* in their Orbs do move;
The higheſt is *Saturn*, thirty year,
He ſpends in compaſſing his Sphere;
Twelve *Jupiter*, and *Mars* in twain,
Sets forward, and comes round again.
Then in one year the Sun diſplays
Three hundred ſixty and five days;
And near a Quarter, which in Four
Encompaſſings, makes one Day more.
Between the Sun and us, there fly
Fair *Venus* and ſwift *Mercury*;
Theſe always near the Sun we find,
Not far before, nor far behind.
The Moon is loweſt, who in ſeven
And twenty Days goes round the Heaven;
And about two Days more doth run,
Before ſhe overtakes the Sun.
So twenty nine and half in all,
Do make a Month Synonidal.
Theſe *Planets* make their courſe to th' Eaſt,
Though they be faſter hurled Weſt;
And ſix Degrees the reſt may ſtray,
Beſide the Suns Ecliptick way.

Job 38. 31,32. *Canſt thou bind the ſweet Influence of the* Pleiades, *or looſe the Bonds of* Orion? *Canſt thou bring forth the* Mazaroth *in his ſeaſon, or canſt thou guide* Arcturus *with his Sons?*

The Circles of the Sphere.

Six greater Circles mark you ſhall,
Which equally divides this Ball;
Juſt in the midſt between the Poles,
From Eaſt to Weſt the *Equator* roles.
The *Ecliptick* cuts him, and doth ſlide
Twenty three degrees and half aſide.
Horizon even with the ground,
From Stars below our ſight doth bound.
Meridian ſtraight upright doth riſe,
Parting the Eaſt and Weſtern Skies.
Two Colures through the Poles do run
Quartring the Circle of the Sun;
One where the Spring and Fall begin;
Th' other where longeſt Days come in:
Four leſſer Circles mark them well,
Are to th' *Equator* Parallel.
Two *Tropicks* bound the Sun's high way,
Shewing the long'ſt and ſhorteſt Day,
The *Arctick* Circle cuts the Bears,
Th' *Antarctick* oppoſite appears.

Meridians half twenty four,
For Hours, and for Degrees nine ſcore,
Through both the *Poles* o'th' World do paſs
And the *Equinoctial* down-right croſs;
And Nineſcore Parallels have that Line,
By which Stars North and South decline.
The *Ecliptick* hath his Longitudes,
And parallels of Latitudes
For Stars; But in *Geography*,
The Towns do from the *Equator lie*.
Over our Head, and under Feet,
The nineſcore *Azimuths* do meet;
And here as many Parallels,
Of Altitude Horizontals
Longitudes and Meridians all,
And *Azimuths* great, Circles call.
But all the Parallels in Heaven,
Being leſſer cut, the Globe uneven.
Degrees three hundred and threeſcore
Hath every Circle, and no more.

The Heavens declare the Glory of God, and the Firmament ſheweth his handy-work, Pſal. 19.1.

When I conſider the Heavens the work of thy Fingers, the Moon, and the Stars which thou haſt ordained, what is Man, that thou art mindful of him? Or the Son of Man, that thou viſiteſt him? Pſal. 8.3.

STURMY'S
Mathematical and Practical
ARTS.

The Sixth BOOK.

Wherein is contained a Definition of the Circles of the Sphere, with the manner how to resolve divers necessary Astronomical Propositions by Projection, and also by the Logarithms.

CHAP. I.

Containing a definition of the Circles of the Sphere.

IN the former Books are contained such *Problems Geometrical* as are most necessary for every ingenious Artist to understand and practise; Now to the end the Practitioner may elevate his Thoughts to the contemplation of those glorious Bodies, the Sun, Moon, and Stars; I shall here in this place exhibit a brief survey of the first Rudiments of *Astronomy*, for the help of young Practitioners and Mariners, for whom chiefly I take this pains; I shall give a brief and succinct Explanation of the several Circles of the *Sphere*, and then shew how to resolve the most usual and common Problems thereof.

1. This is to be understood, that Astronomers do imagine ten principal Points, and ten Circles to be in the Convex side of the first Movable Sphere, which are commonly drawn upon every Globe or Sphere, besides divers other Circles which are not delineated, but only apprehended in the Mind.

The Points are the two Poles of the World, the two Poles of the *Ecliptick*, the two Equinoctial Points, the two Solstitial Points, and the *Zenith* and *Nadir*.

2. The Poles of the World are two Points, which are directly opposite to one another, about which the whole Sphere of Heaven moveth from the East to the West, whereof that which is seen on the North-side the Equinoctial, is called the Arctick or North Pole.

3. The other Diametrically opposite to the former is called the Antarctick, or South Pole, and can be seen only on the South side of the Equator; a right Line imagined to be drawn from the one Pole to the other, is called the Axis of the World.

4. The Poles of the Ecliptick are two Points directly opposite to each other, distant from the North and South Pole of the world 23 *degr.* 31 *min.*

5. The Equinoctial Points are in the beginning of *Aries* and *Libra*, to which Points the Sun cometh about the eleventh of *March*, and thirteenth of *September*, and makes the Days and Nights of equal length in all places in the World.

6. The Point of the Summer *Solstice*, is the beginning of *Cancer*, which the Sun cometh unto about the eleventh of *June*, being the longest day to the Inhabitants on the North part of the Earth, and the shortest day to the Inhabitants of the South part.

7. And the Point of the Winter *Solstice*, is the beginning of *Capricorn*, to which the Sun cometh about the eleventh of *December*, and maketh the shortest Day of the year to the Inhabitants of the North Hemisphere, and the longest to the Inhabitants on the South side the Equinoctial.

8. The *Vertical* Point, or *Zenith*, is the Point directly over-head, and is the Pole of the Horizon, being 90 degrees every way therefrom.

9. The *Nadir* is the opposite Point under our Feet.

Circles of the Sphere.

The ten Circles are as followeth; The Equinoctial, likewise called the Equator, dividing the Heavens in the middle between the two Poles; the two Points of *Aries* and *Libra*, cut this Circle in opposite Points, and when the Sun is in those Points it makes the Days and Nights of equal length over all the World.

2. The Meridian of a place is a great Circle passing through the Poles of the World, and the Zenith of the Place; the Sun when he comes to this Meridian, it is Noon there.

3. The Horizon is distinguished by the names of rational, or sensible; the first is a great Circle every where Equidistant from the Zenith, and divides the superiour or upper Hemisphere, from the lower; the situation of the Sphere is distinguished by the Horizon, which is either Right, Oblique, or Parallel.

A right Horizon passeth through the Poles of the World, and cuts the Equator at right Angles.

An Oblique-Horizon is such an one as cuts the Equinoctial Obliquely, having Latitude from the Equator.

A Parallel-Horizon is one that hath the Poles of the world in the *Zenith* and *Nadir*, and the Equinoctial for the Horizon.

The Sensible-Horizon is a Circle that divideth the part of the Heavens, which we see, from the part we see not, called the *Finitor*.

4. The

4. The Ecliptick is a great Circle, that divides the *Equator* into two equal parts; the Points of Intersection are *Aries* and *Libra*, the one half declining toward the North, the other to the South 23 degrees 31 min.

From the Ecliptick the Latitude of the fixed Stars and Planets are numbred both Northward and Southward; the Circumference of this Circle containing 360 deg. is divided into twelve equal parts called Signs, every Sign containeth 30 degrees, and every degree containeth 60 *minutes*, and every minutes 60 *seconds*, and every second 60 *thirds*.

The Names and Characters of the 12 Signs.

♈	♉	♊	♋	♌	♍
Aries.	*Taurus.*	*Gemini.*	*Cancer.*	*Leo.*	*Virgo.*
♎	♏	♐	♑	♒	♓
Libra.	*Scorpio.*	*Sagittarius.*	*Capricornus.*	*Aquarius.*	*Pisces.*

5. The six uppermost are the Northern, and Six undermost the Southern Signs.

Of the Colures.

6. These are two great Circles, (or Meridians) passing through the Poles of the World, crossing one the other at right Angles, and dividing the Equinoctial and the Ecliptick into four equal parts, making thereby the four Seasons of the Year.

7. The Solstitial Colure is a great Circle passing through the Poles of the World, the Poles of the Ecliptick, and the Solstitial Points of *Cancer* and *Capricorn*, shewing the middle of Summer and Winter.

8. The Equinoctial Colure, is a Circle passing by the Poles of the World through both the Equinoctial Points of *Aries* and *Libra*, shewing the beginning of the Spring and Autumn, when Days and Nights are equal.

9. The Tropick of *Cancer* is a lesser Circle of the Sphere, equi-distant from the Equinoctial to the Northward 23 degrees 31 min. wherein when the Sun is, then he enters *Cancer*, and makes his greatest Northern Declination.

10. The Tropick of *Capricorn* is also a lesser Circle, equi-distant from the Equinoctial Southward 23 degrees 31 min. to which when the Sun cometh, he then enters *Capricorn*, and maketh his greatest Southern Declination.

Of the two Polar Circles.

11. These are two lesser Circles, distant as much from the Poles of the World, as the Tropick of *Cancer* and *Capricorn* is from the Equinoctial in which are the Poles of the Ecliptick, which moving about the Poles of the World, describe by their motion the said two Circles; that about the North-Pole is the *Arctick* Circle, and that about the South is the *Antarctick* Circle.

12. The first six are called great Circles, and the other four lesser Circles; by the Centre of a Circle is meant a Point or Prick in the middle of a Circle, from whence all Lines drawn to the Circumference are equal, and are known by the names of *Radius* or *Semidiameters*.

13. That is said to be a great Circle, which hath the same Centre as the Sphere, and divides it into two equal halfs, called *Hemispheres*; and that is a lesser Circle, which hath a different Centre from the Centre of the Sphere, and divides the Sphere into two unequal Portions or Segments.

14. Of

14. Of other Circles imagined, but not deſcribed in a material *Sphere* or *Globe*. Such are the *Azimuths*, *Almicanters*, *Parallels* of *Latitude* and *Declination*.

Azimuth or *Vertical Circles* paſs through the *Zenith*, and interſect the *Horizon* at right Angles; and the *Azimuth* of Eaſt and Weſt is called the Prime *Vertical*.

15. The *Sun* or any *Star* having Elevation or Depreſſion above or below the *Horizon*, is then properly ſaid to have *Azimuth*; but if they be in the *Horizon*, either riſing or ſetting, the Arch of the *Horizon* between the Centre of the *Sun* or *Star*, and the Point of Eaſt or Weſt, is called the *Amplitude*.

16. Circles of *Altitude*, called *Almicanters*, are Circles Parallel to the *Horizon*, and interſect the *Vertical Circles* at right Angles, which are greateſt near the *Horizon*, and leſſer towards the *Zenith*, in which Circles the Altitude of the *Sun*, Moon, or *Stars* above the *Horizon* are accounted, which is an Arch of an *Azimuth*, contained betwixt the *Almicanter*, which paſſeth through the Centre of the *Sun*, Moon, or *Stars*, and the *Horizon*.

17. *Parallels* of Declinations are leſſer Circles, all Parallel to the Equinoctial, and may be imagined to paſs through every degree and part of the Meridian, and are deſcribed from the Poles of the World; in like manner, the Declination of the *Sun* or *Star* is meaſured by the Arch of the Meridian between the *Sun* and *Star*, and the Equinoctial.

18. *Parallels* of *Latitude* in the Heavens, are leſſer Circles deſcribed from the Poles of the *Ecliptick*, and ſerve to define the Latitude of a *Star*, which is the Arch of a Circle contained betwixt the Centre of any *Star* or Planet, and the *Ecliptick* Line, (making right Angles therewith) and counted toward the North or *South* Poles of the *Ecliptick*, and *Sun* never paſſeth out of the *Ecliptick-Line*, and therefore hath no Latitude.

19. The *Longitude* of the *Sun* or *Stars* is meaſured by the Arch of the *Ecliptick*, comprehended between the Point of *Aries*, and a great Circle paſſing from the Poles of the *Ecliptick*, by the *Sun* or *Stars* Centre, and accounted according to the ſucceſſion of the *Signs*.

20. Longitude on the Earth, is an Arch of the Equinoctial contained between any aſſigned Meridian where it begins, and the meridian of any other place, accounted Eaſtward from the firſt place; but in my Tables it is counted Eaſt and Weſt from the Meridian of the *Lizard* terminating at 180 degrees.

21. *Right-Aſcenſion* is an Arch of the Equinoctial (accounted from the beginning of *Aries*) which cometh to the Meridian with the *Sun*, Moon, or *Stars*, or any part of the *Ecliptick*; and by it there are Tables made for the *Sun*, Moon, and *Stars* to know the time of their coming to the Meridian.

22. *Oblique-Aſcenſion*, is an Arch of the Equinoctial between the beginning of *Aries* and that part of the Equinoctial, that riſeth with the Centre of the *Sun* or *Star*, or any portion of the *Ecliptick* in an *Oblique Sphere*.

23. *Aſcenſional-difference* is the difference between the *Right-Aſcenſion*, and the *Oblique-Aſcenſion*, and thereby is meaſured the time of the *Sun* or *Stars* riſing or ſetting before or after ſix.

24. *Elevation* of the Pole is the height thereof above the *Horizon*, which is equal to the diſtance between the *Zenith* and the Equinoctial, whoſe Complement is equal to the diſtance of the *Zenith* from the North or *South* Pole, or the Elevation of the *Equator* above the *Horizon*; theſe Circles I have inſerted, to the end they may be perfectly known, for without them, the Reader cannot well underſtand the following Problems of the *Sphere* that are depending thereon.

CHAP.

CHAP. II.

The Projection of the Sphere in Plano, *represented by the* Analemma.

THe Sphere may be Projected in *Plano* the Parallels being ſtraight Lines, as in the *Analemma*, if the Semi-diameters of the Parallels, be divided in ſuch ſort as the Line of Sines.

This Scheme is fitted for the Latitude of 51 degr. ½, and repreſents the Points and Circles of the Sphere before deſcribed.

The Projection.

Take with your Compaſſes the Chord of 60 degrees, and upon the Centre C deſcribe the Circle H Z O N. (2.) Draw the Diameter H C O which repreſents the Horizon; and at Right-Angles thereunto, croſs it with another Diameter Z C N.

Then for the Latitude of the place, prick off 51 degr. ½ from O to N, and from H to S; and from the ſame Line of Chords, take the Complement of the Latitude 38 degr. ½ and prick it off from H to Æ, and from O to Q, and draw N C S and Æ C Q.

Then take the Suns greateſt Declination 23 degr. ½ and prick off from Æ to G and T, and with the like Chord do the ſame from N to Y and *g*, for the Polar-Circle; and the like do from Q to D and P, and from S to X and ♄; and through theſe Points draw Parallels to the Equator Y *g*, T S D, G *b* P, and X ♄.

And through the Centre draw the Ecliptick-Line T G P; and draw R S Parallel to the Horizon H C O, and any other Parallel of Altitude as 1 *f*.

(1.) Thus are the Points before defined, repreſented in this Diagram; N is the North-Pole, S the South-Pole, *g* the North, X the South-Pole of the Ecliptick; C the Equinoctial-Points of *Aries* and *Libra*.

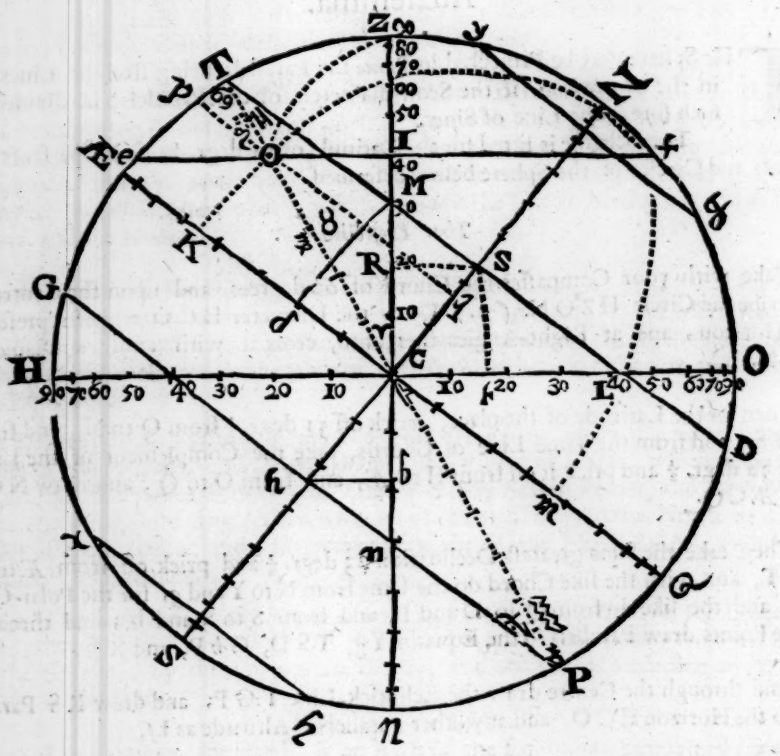
T The point of the *Summer-Solſtice*, P the point of the *Winter-Solſtice*, Z the *Zenith* over our Heads, N the *Nadir-points* under our Feet.

(2.) The greater Circles are H C O the Horizon, Z C N the prime Vertical or Azimuth of Eaſt and Weſt; H Z O N the primary Meridian, and alſo the *Colure* of the *Summer* and *Winter Solſtice*, Æ C Q the Equinoctial; T C P the Ecliptick; S C N the Hour-Circle of 6; and alſo it repreſents the *Colure* of the *Equinoxes*.

(3.) The leſſer Circles are alſo repreſented, T D the Tropick of *Cancer*; G P the Tropick of *Capricorn*; Y *g* the *Arctick-Circle*, about the Pole North; X ♄ the *Antarctick-Circle*.

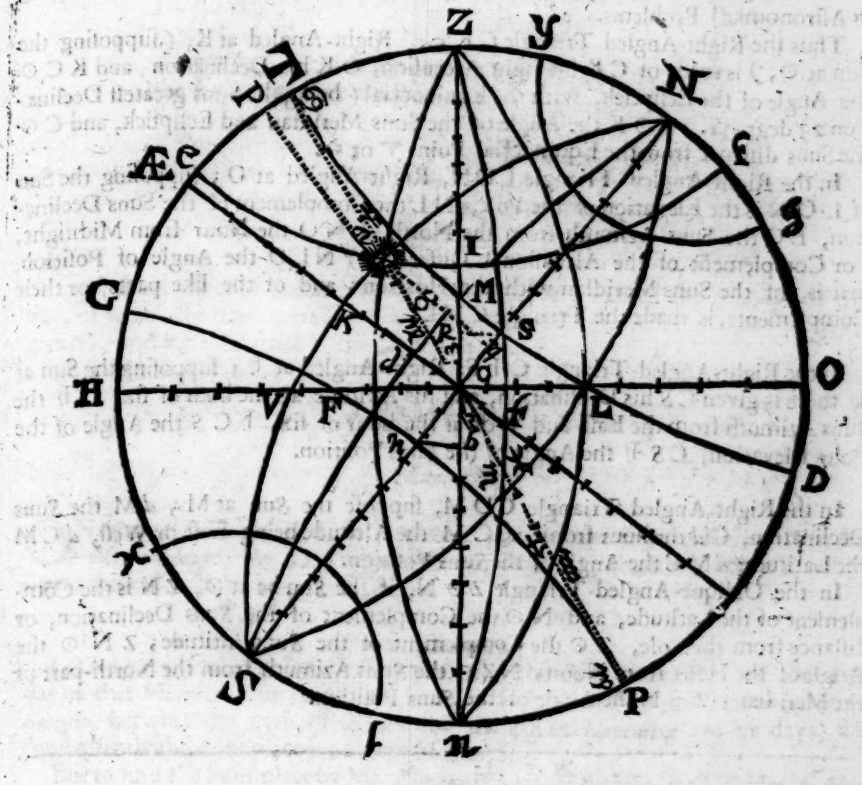
(4.) Other Circles not deſcribed upon Globes, are there repreſented; E *f* repreſents a Parallel of Altitude, called an *Almicanter*; the prickt Arch Z ⊙ repreſents an *Azimuth*.

The Projection of the Sphere in Plano, *according to the* Analemma.



The prickt Arches from the Poles repreſent the Meridian or Hour-Circles, which are *Ellipſes*; the drawing thereof will be troubleſom, and for that reaſon is not mentioned; and how to ſhun them in the reſolution of any Propoſition of the Sphere, by Chords ſhall be ſhewn in the ſeveral Queſtions following; But the Sphere may be Projected in *Plano*, by Circular-Lines, as in the general Aſtrolobe of *Gemma Friſius*, by help of the Tangents, and ½ Tangents on the Scale, as in the fourth Book beforegoing, and will reſolve the ſame things.

The Projection of the Sphere by Circular Lines, called the Stereographick *Projection.*



In this Projection the Circles are distinguished by the same Letters as in the Analemma.

Circles drawn Parallel to the Equinoctial Æ Q, as *p q*, T D, Y *g*: represent Parallels of Declination.

Circles drawn Parallel to the Ecliptick T P, represent Parallels of Latitude of the Stars or Planets.

Arches relating to the motion of the Sun, in either Projection are as follows:

(1.) The Suns Amplitude, or Coast of Rising and Setting, from the East and West, is represented by C L in Northern Sines, and by C F in Southern Sines.

(2.) The Ascensional-difference, or time of Rising and Setting from six, in Summer by S L, in Winter by F *b*.

(3.) The Altitude at Six in Summer by R G; and his Depression at Six in Winter by C *b*.

(4.) The Azimuth at the hour of Six in Summer, by R S, or C *f*, equal to *b b* in Winter.

(5.) The Vertical-Altitude, or Altitude of East and West, by M C in Summer, and his Depression therein in Winter by C N.

(6.) The hour from Six, being East and West, in Summer by M S, in Winter by N *b*.

(7.) The Azimuth from the East or West upon any Altitude, is represented in the Parallel of Altitude, where it intersects the Parallel of Declination by I ⊙.

(8.) The hour of the Day from Six, to any Altitude, is always represented in the said Point of Intersection; in the Parallel of Declination, as by $q \odot$.

This Projection of the Sphere doth represent the Triangles commonly occurring in Astronomical Problems.

Thus the Right-Angled Triangle $C K \odot$, Right-Angled at K, (supposing the Sun at $\odot$,) is made of $C K$ his right Ascension, $\odot K$ his Declination, and $K C \odot$ the Angle of the Ecliptick, with the Equinoctial (being the Suns greatest Declination 23 degr. 31.) $C \odot K$ the Angle of the Suns Meridian and Ecliptick, and $C \odot$ the Suns distance from the Equinoctial Point ♈ or ♎.

In the Right-Angled Triangle $L O N$, Right-Angled at O; supposing the Sun at L $O N$ is the Elevation of the Pole, $N L$ the Complement of the Suns Declination, $L O$ the Suns Azimuth from the North, $L N O$ the Hour from Midnight, (or Complement of the Ascensional Difference) $N L O$ the Angle of Position, that is, of the Suns Meridian with the Horizon; and of the like parts, or their Complements, is made the Triangle $C M L$.

In the Right-Angled-Triangle $C ♄ S$, Right-Angled at ♄; supposing the Sun at S, there is given $C S$ his Declination, and his Altitude at the hour of six, $C ♄$ the Suns Azimuth from the East and West at the hour of six, $♄ C S$ the Angle of the Poles Elevation, $C S ♄$ the Angle of the Suns Position.

In the Right-Angled Triangle $C D M$, suppose the Sun at M; $d M$ the Suns Declination, $C d$ the hour from six, $C M$ the Altitude being East or West, $d C M$ the Latitude, $d M C$ the Angle of the Suns Position.

In the Oblique-Angled-Triangle $Z \odot N$, if the Sun be at $\odot$, $Z N$ is the Complement of the Latitude, and $N \odot$ the Complement of the Suns Declination, or distance from the Pole, $Z \odot$ the Complement of the Suns Altitude; $Z N \odot$ the Angle of the Hour from Noon; $N Z \odot$ the Suns Azimuth from the North-part of the Meridian; $Z \odot N$ the Angle of the Suns Position.

CHAP. III.

How to calculate the Sun's place in the Ecliptick.

THis Proposition is propounded, in the first place, because many others depend upon it, there is ascribed to the Sun a Triple Motion; first, a Motion upon his own Axis, whereby he finisheth one Revolution in 26 Days.

2. A dayly motion from the East into the West, whereby he causeth the Day and Night.

3. An opposite Motion from the West into the East, called the Annual Motion, whereby he runs once in a Year through the Ecliptick, moving near a degree in a day; and thereby causeth the several Seasons of the Year.

The two later Motions may be represented by a man turning a Crane-Wheel, 365 times round, while a Worm struggling against, and contrary to that Motion, creeps once round the contrary way, but Obliquely; that is, from the further side of the Wheel, towards the hithermost; and by this Motion the Sun is supposed to describe the Ecliptick-Line, according to *Tycho*, and the other Planets, (except the Moon) moving round him, being subject to his Motions, and many of their own besides; many of which Motions are removed by the *Copernican* supposition of the Earths Motion, which is a subject of much controversie among the Learned; However, be it either the one, or the other, the Propositions hereafter resolved, vary not; the Proposition is, what Longitude the Sun hath from the neerest Equinoctial Point, which may be found within a degree or two from the day of his Entrance into each Sign.

The

The Day of the Month the Sun enters into each Sign.

♈	Aries,	*March* 10.
♉	Taurus,	*April* 10.
♊	Gemini,	*May* 11.
♋	Cancer,	*June* 11.
♌	Leo,	*July* 13.
♍	Virgo,	*August* 13.
♎	Libra,	*September* 13.
♏	Scorpio,	*October* 13.
♐	Sagittarius,	*Novemb.* 12.
♑	Capricornus,	*Decem.* 11.
♒	Aquarius,	*January* 10.
♓	Pisces,	*February* 8.

1. If the number of the Day of the Month given, exceed the number of that day, in which the Sun enters into any Sign; Subtract the lesser number from the greater, and the Remainer is the Degree of that Sign the Sun possesseth.

PROBL. I.

Example.

ON *May* 12. I would find the Suns true place by the former Rules; The Sun enters *Gemini*, *May* 11; which subtract from 12, the Remainer is 1, which shews the Sun to be in 1 degr. of *Gemini*.

2. *Example.*

Let it be required to know the Suns place the fourth of *November*; on the 11th day of that Month the Sun enters *Sagittarius*, and the 13th day of *October* he enters *Scorpio*, betwixt the 13th of *October* and the 4th of *November* are 22 days, and consequently the Suns place is 22 degr. of *Scorpio*.

But to find the Suns place by Mr. *Vincent Wing*'s *Hypothesis*, and Tables in *Astronomia Britannica*, the Rule is,

First, enter the Table of the Middle-Motion and *Apogee* of the Sun, and write out the *Epocha* next going before the time given, under which set the Motion belonging to the Years, Months, Days, Hours, and Minutes, (only in the *Bissextile* or *Leap-years*,) after *February* a Day is to be added to the number of days given; then adding them all together, the sum will be the Middle-Motion and *Apogee* of the Sun for the time given.

As for Example.

Suppose the time given be the 12th of *May* at Noon 1667, at which time the Suns place is required.

Time given.	Longitude ☉				Apog. ☉			
	S	D	M	S	S	D	M	S
The *Epocha*	9	20	24	49	3	6	45	5
1661, years Including 6, *May*	11	29	33	07	0	0	6	10
Days 12.	3	28	16	39				20
	0	11	49	40				2
The Suns Mean-motion, or Longitude.	2	00	04	15	3	6	51	37

2. Subtract the *Apog.* of the Sun from his Mean-Longitude, and the Remain will be his Mean Anomaly.

Example.

	S	D	M	S
The Suns Mean-Longitude is	2	00	04	15
The *Apogæum* subtracted	3	06	51	37
The Suns *Anomaly*	10	23	12	38

With the *Suns Anomaly* enter the Table of his Equation with the *Sign* on the Head and the degr. descending on the left hand, if the number thereof be under 6 *Signs*; but if it be more than 6 *Signs*, enter with the *Sign* in the bottom, and the degr. ascending on the right hand, and in the common-Angle you have the Equation answering thereunto; only you must, (if need require,) take the Proportional part.

Example.

	S	D	M	S
In the Table of Equation answering to 23 *d.* 12 *m.* 38 *S* is	0	01	11	31
The *Suns* Mean-Longitude, add	2	00	04	15
The *Suns* true Longitude.	2	01	15	46

Therefore the true place of the *Sun* is in 1 *degr.* 15 *min.* 46 *seconds* of *Gemini.*

Another Example.

In the Year 1583, *March* 14 at Noon, in the Meridian of *Uraniburg* in *Denmark*, the thrice Noble *Tycho-Brahe*, observed the *Suns* true place in 3 *deg.* 17 *m.* 40 *seconds* of *Aries.* The time at *London* was *March* 13, 23 *h.* 8 *m.*

Multiply 53 by 11, the Product is 583, which divide by 60, the Quotient will be $9\ ''\frac{43}{60}$, or 10″, and because the Equation decreases I subtract it from the Equator, answering to 22 *degr.* and it leaves 1 *d.* 52 *m.* 12″, for the true Equation desired; which according to the Title, being added to the *Suns* Mean Longitude, giveth the true place of the *Sun* required, as follows:

	S	D	M	S
The *Suns* Mean-Longitude	0	29	00	30
The Equation added	1	52	12	
The *Suns* true Longitude	1	00	52	42

Therefore the *Suns* true place is in 0 *deg.* 52 *min.* 42 *Seconds* of *Taurus*; these Examples are sufficient for Direction, to find the *Suns* true place at any time.

Probl. II.

The Suns distance from the next Equinoctial-Point; and his greatest Declination being given, to find the Declination of any Point required.

Note, the Horizon needed not to have been delineated in this Problem, but the same Scheme refers to the Problems following, and therefore it was drawn.

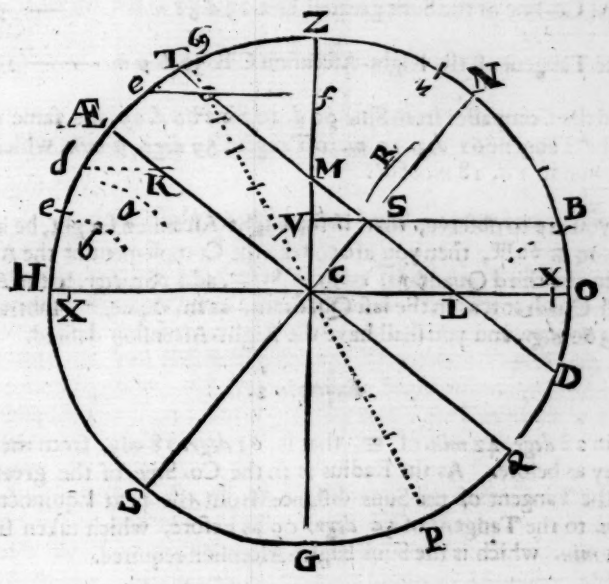
With your Compasses take the Chord of 60 degr. upon the Centre C, describe the Circle H Z O N, and draw the Diameter H C O, which represents the Horizon, and at Right-Angles, or Perpendicular thereunto, draw Z C N, the Azimuth of East or West, and take the Latitude of the place, (which in this Example is 51 *d.* $\frac{1}{2}$,) and prick it from O to N, and from H to *S*, and draw the Hour of Six N C *S*; then prick from Z to Æ, and from N to Q 51 degr. $\frac{1}{2}$, and draw the Equinoctial Line Æ C Q; then the *Suns* place being given, take 23 *deg.* 31 *m.* and prick from Æ to ♋, and from Q to ♈, and draw the prickt Line ♋ C ♈, then take the *Suns* distance from the next Equinoctial-Point, which in this Example shall be 61 *deg.* 18 *m.* out of the Line of *Sines*, and prick it from C to ☉, and through

through ⊙ draw a Parallel-Line to the Equinoctial, as T D, and it ſhall be a Parallel of Declination, and where it cuts the outward Meridian, as at T, apply the diſtance Æ T to the Line of Chords, and you have the Declination 20 *deg.* 30 *min.* which was required; Or you may take the neareſt diſtance from ⊙ to the Equator, and apply it to the Line of Sines, and that will give you the declination 20 *deg.* 30 *min.* and if through ⊙ you draw a Line Parallel to the Horizon H O, as *e f*, it is a Parallel of the Suns Altitude.

By the Logarithms in the Right-Angled Triangle C K ⊙; in the *Stereographick* Projection we have given, firſt the *Hypothenuſe*, C ⊙ 61 *deg.* 18 *min.* ſecondly, the Angle K C ⊙ 23 *deg.* 31 *m.* hence to find K ⊙, as the *Radius* —— 10
is in proportion to the Sine of the Suns Declination 23 *d.* 31 *m* K C ⊙ 960099
So is the Sine of the Suns diſtance from the next Equinoctial-Point
61 *degr.* 18 *min.* C ⊙ —— 994307

to the Sine of his Declination required 20 *deg.* 30 *min.* ——
K ⊙ —— 954406

Or extend the Compaſſes in the Line of Artificial Sines from 90 *degr.* to 23 *deg.* 30 *min.* the ſame extent will give the diſtance from the Suns place to his Declination.



The Sun being either in 1 *deg.* 18 *min.* of *Gemini*, or 29 *deg.* 42 *min.* of *Capricorn*, or 1 *degr.* 18 *min.* of *Sagittarius*, or 28 *degr.* 42 *min.* of *Cancer*; that is, 61 *degr.* 18 *min.* from the next Equinoctial-Point; the Declination will be found to be 20 *deg.* 30 *min.*

PROBL.

Probl. III.

Having the Suns greateſt Declination, and his Diſtance from the next Equinoctial Point; to find his Right-Aſcenſion.

IN the foregoing Scheme, having drawn the Parallel of the Suns Declination T D, paſſing through the Suns place at ☉ the extent S ☉ is the Sine of the Suns Right-Aſcenſion from the next neareſt Equinoctial-Point, to the Radius of the Parallel T D; and therefore place the extent S T from C to X, and upon X as a Centre with the extent S ☉, deſcribe the Arch at R, a Ruler laid from the Centre juſt touching the extremity of that Arch, finds the Point N in the Limb of the Meridian, and the Arch O N, applied to the Line of Chords, is 59 *degr.* $\frac{1}{6}$, and ſo much is the Suns Right-Aſcenſion in the firſt quarter of the Ecliptick.

In the Triangle C K ☉ we have given as before, (1.) the Angle of the Suns greateſt Declination K C ☉ 23 *degr.* 31 *m.* (2.) the Longitude of the Sun from the next Equinoctial-Point *Aries* C ☉ 61 *degr.* 18 *min.* hence to find the Suns Right-Aſcenſion, the proportion,

As the Radius ——— 10
to the Tangent of the diſtance 61 *degr.* 18 *min.* C ☉ ——— 1026162
So is the Co-ſine of the Suns greateſt Dec. 23 *d.* 31 *m.* K C ☉ —— 996234

to the Tangent of the Right-Aſcenſion C K 59 *d.* 9 *m.* ——— 1022396

Or extend the Compaſſes from Sine 90 *d.* to Sine 66 *d.* 29, the ſame diſtance will reach from the Tangent 61 *deg.* 19 *m.* to Tangent 59 *degr.* 9 *min.* which is the Suns Right Aſcenſion in 1 *d.* 18 *m.* of ♊.

But this you are to obſerve, that if the Right-Aſcenſion ſought, be in the ſecond Quadrant as in ♋ ♌ ♍, then you are to take the Complement of the Arch found to 180 *deg.* if in the third Quadrant, as in ♎ ♏ ♐, add 180 *degr.* to the Arch found; but in the laſt Quadrant, as in the laſt Quadrant, as in ♑, ♒, ♓, ſubtract the Arch found from 360 *degr.* and you ſhall have the Right-Aſcenſion deſired.

Example 2.

The Sun in 28 *degr.* 42 *min.* of ♋, that is, 61 *degr.* 18 *min.* from the Equinoctial Point ♎; ſay as before. As the Radius is to the Co-Sine of the greateſt Declination, ſo is the Tangent of the Suns diſtance from the next Equinoctial-Point 61 *degr.* 18 *min.* to the Tangent of 59 *degr.* 09 as before, which taken from 180, is 130 *degr.* 51 *min.* which is the Suns Right-Aſcenſion required.

Example 3.

The Sun in 1 *degr.* 18 *min* of ♐ that is, 61 *degr.* 18 *min.* from the next Equinoctial-Point ♎, the work is the ſame as before; therefore to the Arch found I add 180 *degr.* makes 239 *degr.* 09 *min.* the Right-Aſcenſion of the Sun ſought.

Example 4.

The Sun in 28 *degr.* 42 *min.* of ♑, 61 *degr.* 18 *min.* from the next Equinoctial Point ♈, the operation is the ſame with the former Example; wherefore ſubtract the Arch found 59 *deg.* 09 *min.* from 360 *deg.* and there will remain 300 *deg.* 51 *min.* which is the Suns Right-Aſcenſion required.

Probl.

PROBL. IV.

The Elevation of the Pole, and Declination of the Sun being given; to find the Ascensional Difference.

THis is represented in the Figure by S L in the Parallel of Declination, and it is therefore to be reduced into the common Radius, therefore take the Radius of the Parallel S T, and prick it from C to X, as before; then take the extent S L, and setting one Foot upon X, with the other draw the part of an Arch at *a*, lay a Ruler from C, that it may just touch the outside thereof, and it cuts the Circle in *d*, and take the Chord or Extent H *d*; and you will find it 28 *degr.* which being converted into Time, is 1 hour 52 *min.* and so much doth the Sun rise before, and set after Six in Summer; but so much doth he rise after, and set before Six in Winter.

In the Right-Angled Spherical Triangle S L C are known. 1. S C L the Complement of the Poles Elevation 38 *deg.* 28 *min.* 2. The Suns Declination 20 *deg.* 30 *min.* hence to find the Ascensional Difference *S* K.

As the Radius is in Proportion	10
to the Tangent of the Latitude, 51 *deg.* 28 *min.*	10.09888
So is the Tangent of the Suns Declination 20 *deg.* 30 L *S-*	9.57274
to the Sine of *S* K the Ascensional difference 28 *d.* 00 *m.*	9 67162

PROBL. V.

The Suns Right-Ascension, and his Ascensional difference being given; to find his Oblique Ascension, and Descension.

TO perform this, you must observe these two following Rules. 1. If the Suns Declination be North, you must subtract the Ascensional-Difference from the Right-Ascension, and the Remainer will be the Oblique-Ascension; but if you add them together, the sum will be the Oblique Descension. 2. If his Declination be South, add the Ascensional-difference, and the Right Ascension together, the sum will be the Oblique-Ascension; but if you subtract it, the Remainer will be the Oblique-Descension.

Admit the Sun is in the 1 *deg.* 18 *min.* of *Gemini* by the second Problem, his Right-Ascension is 59 *deg.* 09 *min.* and his Ascensional-difference by the fourth Problem, is 28 *deg.* 0 *min.* therefore according to the first Rule, because his Declination is North, the difference 31 *deg.* 09 *min.* is the Suns Oblique-Ascension, and the sum of them 87 *deg.* 09 *min.* his Oblique Descension.

PROBL.

PROBL. VI.

To find the time of Sun-Rising, and Setting, with the length of the Day and Night.

YOu must find the Ascensional-difference by the fourth Problem, which converted into Time, allowing 4 *min.* of an hour for every *degr.* and 4 seconds for every *min.* and the sum of Hours and Minutes, is his difference of Rising and Setting before or after the hour of Six, which was found before to be 28 *degr.* or 1 hour 52 *min.*

Therefore when the Sun is in Northern Sines, add the sum to Six, and the Total is the Semi-diurnal Arch, as in this Example, is 7 *hours*, 5 *min.* 2 ″, the time of Sun-setting, and subtract it from 6, and the Remain is 4 *hour*, 7 *m.* the time of Sun-Rising; double 7 *hours*, 52 *min.* it is 15 *hours*, 44 *min.* the length of the Day, subtract it from 24 *hours*, 00 *min.* and the Remain is 8 *hours*, 16 *min.* the length of the Night in the Lat. of *Bristol*, 51 *d.* 28 *m.* Nor.

PROBL. VII.

The Elevation of the Pole, and Declination of the Sun being given; to find his Amplitude.

MEasure the extent C L with the Compasses in the Line of Sines, and it will reach to 34 *d.* 40 *m.* and so much doth the Sun rise and set to the Northward of the East and West in the Latitude of 51 ½ No. when his Declination is 20 *deg.* 30 *min.* North; but he riseth and setteth so much to the Southward of the East and West, when his Declination is so much South.

In the Right-Angled Spherical-Triangle L S C, having the Angle L C S, the Complement of the Latitude 38 *deg.* 32 *min.* and L S the Suns Declination 20 *deg.* 30 *min.* (in 1 *d.* 18 *m.* ♊) his Amplitude by Calculation may be found thus.

As the Co-sine of the Latitude 51 *deg.* 28 *min.* L C S —— 979447

is to the Radius 90 *deg.* —— 10

So is the Sine of the Declination 20 *degr.* 30 *min.* L S —— 954432

to the Sine of the Amplitude C L 34 *deg.* 12 *min.* —— 974985

This is in common use for the finding of the Variation of the Compass at Sea, by comparing the Coast, or Amplitude of the Sun, observed by an Amplitude or Azimuth-Compass at the Suns rising or setting, and by his Amplitude (found by this proportion) the difference sheweth the Variation.

As for Example.

Admit you observed the Suns Amplitude of Sun Rising by your Compass described in the first Chapter and fifth Book of this Treatise.

By the Compass, the Magnetical Amplitude —— 45 *deg.* 55 *min.* North-easterly.
By the Rules beforegoing find the true Amplitude, 34 *deg.* 40 *min.* North-easterly.

Subtract the less out of the greater, the difference 11 *deg.* 15 *min.* Variation.

And

And by reaſon the Magnetical Amplitude is farther from the North at *Sun* riſing than the true Amplitude; therefore the Variation 11 *deg.* 15 *min.* (which is one Point) is Weſterly; and if you are bound to a place that bear North of you, you muſt ſail North by Eaſt; or if you bear Weſt, you muſt ſail Weſt and by North; and if *South*, the Courſe muſt be *South* by Weſt; or if you bear Eaſt, then the Courſe muſt be Eaſt by *South*; and ſo of all the reſt of the Points you muſt allow in like manner.

2. But admit the Magnetical Amplitude at *Sun* ſetting obſerved by the Compaſs were 23 *deg.* 25 *min.* from the Weſt toward the North, and the true Amplitude found to be 34 *degr.* 40 *min.* the ſame way the difference is 11 *degr.* 15 *min.* and by reaſon the Magnetical Amplitude at *Sun* ſet is farther from the North than the true Amplitude, the Variation is Eaſterly; and ſo the North Point of the Compaſs is the N by E, and N E is N E by E, and E is E by *S*, and *South* is *S* by W, and W is W by N.

PROBL. VIII.

Having the Latitude of the Place, and the Suns Declination, to find the time when the Sun cometh to be due Eaſt or Weſt.

IN the Parallel of Declination 20 *deg.* ½ Northerly the hour from *Six* is repreſented by *S* M, with that extent upon the Point X draw the Arch *b*, the Ruler laid from C to touch the ſaid Arch, cuts the Circle at (*e*,) the diſtance O *e* applied to the Line of Chords ſheweth 17 *deg.* ¼ *min.* it converted into Time is 1 *h.* 9 *m.* and ſo much after ſix in the Morning, and before ſix in the Afternoon, wil the *Sun* be due Eaſt or Weſt.

Suppoſe the Latitude 51 *deg.* 28 *min.* and Declination North 20 *degr.* 30 *min.* therefore in the Right-Angled *Spherical* Triangle Z N M are given (1) Z N the Complement of the Latitude 38 *deg.* 32 *min.* (2) N M the Complement of the *Suns* Declination 69 *deg.* 30 *min.* Then I ſay,

As the Radius 90 is in proportion. —— 10
To the Co-Tangent of N M the compl. of the Declination 69 *d.* 30 *m.* 957274
ſo is the Tangent of Z N compl. of Latitude 38 *deg.* 32 *min.* —— 990112

is to the Co-*Sine* of Z N M 17 *d.* 19 *m.* which reduced is 1 *h.* 9 *m.* of time, —— 947386

Which 1 *h.* 9 *m.* added to 6 *h.* is 7 *h.* 9. *m.* the time in the morning the *Sun* will be due Eaſt; and if you ſubtract 1 *h.* 9 *m.* from 6 *h.* 00 *m.* and the Remain will be 4 *h.* 51 *m.* the time in the Afternoon the *Sun* will be due Weſt.

PROBL. IX.

The Elevation of the Pole, and the Declination of the Sun being given; to find the Suns Altitude being due Eaſt or Weſt.

TAke the extent C M on the Vertical-Circle, and apply it to the Line of *Sines*, and it will reach to 26 *deg.* ½, and ſo much is his Altitude ſought in *Summer*; if the *Suns* Parallel of Declination T M doth not meet with the prime Vertical Circle C Z, the *Sun* cometh not to the Eaſt nor Weſt, as it hapneth in Countries betwixt the Tropicks.

In the former Diagram, the *Suns* Altitude when he is due Eaſt and Weſt, is ſhewed by the Arch C M, wherefore in the Triangle C V M we have given (1) the

Suns Declination V M 20 *deg.* 30 *min.* (2) the Angle of the Poles Elevation M C V 51 *deg.* 28 *min.* to find his Altitude C M; I say,

As the Sine of the Latitude 51 *deg.* 28 *min.* U C M ——— 9°9334
is to the Sine of the Declination 20 *deg.* 30 *min.* U M — 954432
So is the Radius 90 *deg.* ——— 10

to the Sine of the Altitude 26 *deg.* 35 *min.* C M. ——— 965098

Probl. X.

The Elevation of the Pole, and Declination of the Sun being given, to find the Suns Altitude at the Hour of Six.

TAke the neareſt diſtance from S to the Horizon C L, and apply it to the Line of Sines ſheweth the Altitude to be 16 *deg.* and ſo much is his Depreſſion under the Horizon at ſix, when he hath South-Declination 20 *degr.* 30 *min.* in Northern Latitudes.

In the Triangle Z S N, (1.) The Complement of the Latitude Z N 38 *deg.* 32 *min.* (2.) the Complement of the Suns declination N S 69 *deg.* 30 *min.* to find the *Hypotenuſe* Z S; therefore I ſay,

As the Radius ——— 10
To the Co-ſine of 69 *deg.* 30 *min.* N S ——— 954432
ſo is the Co-ſine of 38 *degr.* 32 *min.* Z N ——— 989334

To the Co-ſine Z S the compl. of the Altitude 74 *d.* 6 *m.* — 943766

Whoſe compl. is 15 *degr.* 54 *min.* the Suns Altitude at the hour of ſix, when the Declination is 20 *deg.* 30 *m.* North, in the Latitude 51 *deg.* 28 *min.* Extend the Compaſſes from Sine 90 *deg.* to Sine 20 *deg.* 30 *m.* the ſame extent will reach from the Sine of the Latitude 51 *deg.* 28 *min.* to Sine of 15 *deg.* 54 *m.*

Probl. XI.

Having the Latitude of the place, and the Declination of the Sun given; to find the Suns Azimuth at the hour of Six.

THis is repreſented by V Z in the Parallel of Altitude of the Sun V S B; Prick V B from C to W, from thence with the diſtance V S draw the Arch at *b*, and lay the Ruler from C juſt touching the ſaid Arch, it cuts the Circle in Y; the diſtance H Y meaſured on the Chords ſheweth the Azimuth to be 13 *deg.* and ſo much is the Sun to the Northwards of the Eaſt or Weſt at the hour of Six.

In the Right-Angled Spherical Triangle Z N S of the general Diagram, we have known firſt, Z N, the Complement of the Latitude 38 *deg.* 32 *min.* (2.) N S the Complement of the Suns Declination 69 *deg.* 30 *min.* to find the Azimuth of the hour of ſix, repreſented by the Angle N Z S.

I ſay,

As the Radius ——— 10
to the Sine Compl. of the Latitude 38 *d.* 32 *m.* Z N -- 979447
So is the Co-Tangent of N S 69 *deg.* 30 *m.* ——— 957274

to the Co-Tangent of N Z S the Azimuth from the North 76 *d.* 54 *m.* ——— 936721

Or

Or extend the Compasses from the Radius to the Co-Sine of the Latitude, the same extent will reach from the Tangent of the Declination, to the Tangent of the Azimuth 13 *deg.* 6 *min.* from the East or West Northerly.

PROBL. XII.

The Latitude of the Place, the Suns Declination and the time from noon being given, to find the Suns Altitude.

Example.

IN the Latitude 51 *deg.* 28 *min.* Nor. the Suns Declination 23 *deg.* 31 *min.* North or South, to find the Suns Altitude at any hour.

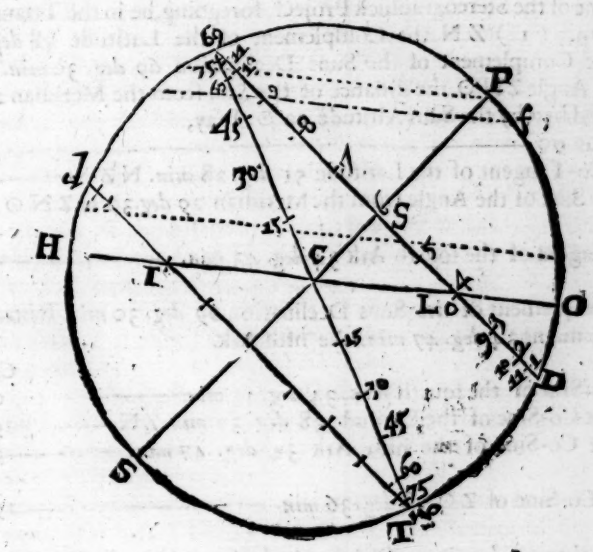
By the Orthographick Projection.

Take the Chord of 60 *degr.* and describe the Arch H T P, draw the Horizontal-Line H C O. and from O to B prick off the Chord of the Latitude 51 *degr.* 28 *min.* and from P and S to I and D set off the Complement of the Suns greatest Declination, 66 *degr.* 29 *min.* and draw the Parallels of Declination ♋ D and *d* ♑, and P C S the hour of Six; then draw T C, which is the Ecliptick-Line, and take off the Line of Sines, and prick down

15, 30, 45, 60, 75	*degr.* for the Hours of	1, 2, 3, 4, 5 from 6 before it, and after it upon the Ecliptick

Then take the neareſt diſtance from 15 *degr.* to C S, the hour of Six, or *Axis*, and prick it from S to 5 and 7; and likewiſe take the neareſt diſtance from 30 to C S, and lay it from S to 8 and 4; and in like manner do with the reſt, then will the neareſt diſtance from 4, 5, 6, 7, 8, 9, 10, 11, to the Horizontal-Line H C O be the Sines of their reſpective Altitude;

ſo the Altitude for the hours	4, 5, 6	In Summer will be	1 *deg.* 34 *min.*, 9 30, 18 12



And ſo much is the Suns Depreſſion under the Horizon at the hours of 8, 7 and 6 in Winter.

The Summer Alt. for the hours of	7, 8, 9, 10, 11	are	27 : 23, 36 : 42, 45 : 42, 53 : 45, 59 : 42

And the Winter Altitude for

the Hours of	9, 10, 11	are	5 *d.* 13, 10 : 28, 13 : 48

Example 2.

Admit the Latitude were 51 *deg.* 28 *min.* and his Declination 00 *deg.* 00 *m.* and the time from Noon is 2 *ho.* 44 *min.* or 41 *deg.* 00 *m.* and the Sun being upon the Equinoctial.

In the Stereographick Projection beforegoing, in the Triangle Z Æ K, we have given firſt Æ Z the diſtance from the Zenith to the Equator, equal to the Latitude of the place, 51 *deg.* 28 *min.* Secondly, Æ K the Suns diſtance from the Meridian 41 *deg.* to find Z K the Complement of the Suns Altitude.

The Operation by the Logarithm.

As the Radius 90 *deg.* —— 10
is to the Co-Sine of the Suns diſtance from the Merid. 41 *d.* 0 *m.* Æ K —— 987778
So is the Co-Sine of the diſtance from the Equa. to the Zen. 51 *d.* 28 *m.* Æ Z —— 979447

to the Co-Sine of Z K 61 *deg.* 58 *min.* —— 967225

Whoſe Complement to 90 *deg.* is the Altitude 28 *deg.* 02 *min.* which was required.

Example 3.

Let it be required to find the Suns Altitude at 10 a clock and 2 *m.* before Noon, when the Sun is in 1 *deg.* 18 *min.* of *Gemini* the Declination being 20 *deg.* 30 *min.* Northerly in the Latitude 51 *deg.* 28 *min.* Nor.

In the Scheme of the Stereographick Project. foregoing, be in the Triangle N Z ⊙, we have known, (1.) Z N the Complement of the Latitude 38 *deg.* 32 *min.* (2.) N ⊙, the Complement of the Suns Declination 69 *deg.* 30 *min.* (3.) the comprehended Angle Z N ⊙, the diſtance of the Sun from the Meridian 29 *d.* 30 *m.* to find Z ⊙. and hereby the Suns Altitude 92 ⊙, I ſay,

As the Radius 90 —— 10
is to the Co-Tangent of the Latitude 51 *deg.* 28 *min.* N Z —— 990112
So is the Co-Sine of the Angle from the Meridian 29 *deg.* 30 *m.* Z N ⊙ 993962

to the Tangent of the fourth Ark 34 *deg.* 43 *min.* —— 984074

From the Complement of the Suns Declination 69 *deg.* 30 *min.* ſubtract 34 *deg.* 43 *min.* there remains 34 *deg.* 47 *min.* the fifth Ark.

Co-Arith.

As the Co-Sine of the fourth Ark, 34 *deg.* 43 *min.* —— 008514
is to the Co-Sine of the Latitude 38 *deg.* 32 *min.* Z N —— 989334
So is the Co-Sine of the fifth Ark 34 *deg.* 47 *min.* —— 991451

to the Co-Sine of Z ⊙ 38 *deg.* 36 *min.* —— *x*989299

Whoſe Compl. to 90 *deg.* is 51 *deg.* 24 *min.* the Suns Altitude above the Horizon being in 1 *deg.* 18 *m.* of ♈ in Latitude of 51 *deg.* 28 *min.* North.

Suppoſe

Suppose the Sun in 1 *deg.* 18 *min.* of *Sagittarius*, having South-Declination 20 *d.* 30 *min.* and the *ho.* 1. 59 *min.* 52 ″, afternoon.

In the Scheme of the *Stereographick Projection* beforegoing, in the Oblique-Angled Triangle Z N ⊙. 1. N Z the Complement of the Latitude 38 *deg.* 32 *min.* 2. N ⊙, 110 *deg.* 30 *m.* the distance from the North-Pole. 3. The Angle Z N ⊙ 29 *deg.* 58 *m.* to find the Z ⊙ the Complement of the Suns Altitude to 90 *deg.*

The Operation.

As the Radius 90	10
is to the Tangent of N Z 38 *degr.* 32 *min.*	990112
So is the Co-sine of the Angle, Z N ⊙, 29 *d.* 58 *m.*	993768
to the Tangent of 34 *deg.* 36 *min.* the fourth Ark,	983889

From the Ark N ⊙ 110 *deg.* 30 *min.* subtract the fourth Ark 34 *deg.* 36 *min.* and there remains 75 *deg.* 54 *min.* the fifth Ark.

	Co-Arith.
As the Co-Sine of 34 *deg.* 36 *min.*	008453
is to the Co-Sine of Z N 38 *deg.* 32 *min.*	989334
So is the Co-Sine of the fifth Ark *q* ⊙ 75 *deg.* 54 *min.*	938670
to the Co-Sine of Z ⊙ 76 *deg.* 37 *min.*	936457

Now the Complement of Z ⊙, is 13 *deg.* 23 *min.* which is the Suns Altitude required.

PROBL. XIII.

The Suns Altitude, the time from Noon, and the Declination being given; to find his Azimuth.

Example 1.

THE Suns Altitude 51 *deg.* 12 *min.* the time 9 *ho.* 49 *min.* 52 ″ in the forenoon, and the Suns Declination 20 *deg.* 30 *min.* North, to find his Azimuth.

In the Oblique Spherical-Triangle Z N ⊙, we have known. 1. Z ⊙ the Complement of the Suns Altitude 38 *deg.* 48 *min.* 2. The Angle Z N ⊙ 29 *deg.* 58 *m.* the Suns distance from the Meridian. 3. The complement of the Suns Declination N ⊙ 69 *deg.* 30 *m.* See the Scheme of the *Stereographick* Projection before-going.

The Operation by the Log.

	Co-Arith.
As the Co-Sine of the Altitude 38 *deg.* 48 *min.* Z ⊙	020301
is to the Sine of the Angle from the Merid. 29 *deg.* 58 *m.* Z N ⊙	969853
So is the Co-Sine of the Declination 69 *degr.* 30 *min.* N ⊙	997159
to the Sine of the Suns Azimuth N Z ⊙ 13 *deg.* 42 *min.*	987313

The Azimuth from the North. Example 2.

Now admit the Altitude were 13 *deg.* 23 *min.* the time 1 *ho.* 59 *min.* 52 *sec.* after noon, and his Declination South 20 *deg.* 30 *min.*

In the general Diagram of the *Stereographick Projection* you have in the Oblique-Angled Spherical Triangle Z N ⊙, 1. Z ⊙ the Complement of the Suns Altitude 76 *deg.* 37 *min.* 2. The Angle Z N ⊙ 29 *deg.* 58 *min.* his distance in time from the Meridian. 3. N ⊙ 110 *deg.* 30 *min.* the distance of the Sun from the North Pole.

To

To find the Angle N Z ⊙ the Suns Azimuth from the North.

The Operation.

		Co-Arith.
As the Co-Sine of the Altitude Z ⊙ 76 *deg.* 37 *min.*		001196
is to the Sine of the Angle from the Merid. Z N ⊙ 29 *d.* 58 *m.*		969853
So is the Co-Sine of the Polar distance N ⊙ 110 *d.* 30 *m.*		997159
to the Sine of the Suns Azimuth N Z ⊙ 151 *d.* 16 *m.*		*x*968208

PROBL. XIV.

The Latitude of the place, the Suns Declination and his Altitude being given, to find the Suns Azimuth.

Example 1.

IN the Latitude 51 *deg.* 28 *min. Nor. the Suns Declination being* 20 *deg.* 30 *min. Nor. and his Altitude* 51 *deg.* 12 *min. to find the Suns Azimuth.*

In the former Diagram, in the Oblique-Angled Triangle Z ⊙ N, there are given the three Sides, Z N 38 *deg.* 32 *min.* the Complement of the Latitude, N ⊙ 69 *deg.* 30 *min.* the Complement of the Declination, and Z ⊙ 38 *deg.* 48 *min.* the Complement of the Altitude, to find the Angle N Z ⊙, the Suns Azimuth from the North.

The Operation by the Logarithms.

The containing Sides	Z N 38 *deg.* 32 *min.*	Co-Arith. Sine	0.20553
	Z ⊙ 38 *deg.* 48 *min.*	Co-Arith. Sine	0.20301
The oppofite fide N ⊙ 69 *d.* 30 *m.*	half fum, 73 *d.* 25 *m.*	Log. Sine	9 98155
The fum of the fides 146 *d.* 50 *m.*	Remain. or Dif. 3 *d.* 55 *m.*	Log. Sine	8.83445
The half Sum 73 *d.* 25 *m.*		Sum of the 4 Logarith.	19.22454
The Diff. of the oppofite fide from the half Sum, called the Remainder, 3 *d.* 55 *m.* is	*Sc.* 65 *d.* 50 *m.*	half Sum	9.61227
	65 *d.* 50 *m.*	which doubled	
	131 *d.* 40 *m.*	the Suns Azimuth from the Nor.	

Whofe Complement to 180 *d.* 48 *d.* 20 *m.* is the Azimuth from the South.

Example 2.

In the Latitude 51 *d.* 28 *m. North, the Suns Declination being* 20 *d.* 30 *m. South, and his Altitude* 13 *d.* 23 *m. to find the Suns Azimuth.*

In the former Diagram, in the Oblique Triangle Z ⊙ N (where the Declination is Southerly) there is given the three fides, N Z 38 *deg.* 32 *m.* the Complement of the Latitude, Z ⊙ 76 *deg.* 37 *min.* the Complement of the Altitude, and N ⊙ 110 *deg.* 30 *min.* the Suns diftance from the North Pole, to find the Angle N Z ⊙, the Suns Azimuth from the North.

The

The Operation by the Logarithms.

The containing Sides	Z N 38 *deg.* 32 *min.*	Co-Arith. Sine	0.20553
	Z ⊙ 76 *deg.* 37 *min.*	Co-Arith. Sine	0.01196
The oppoſite ſide N ⊙ 110 *d.* 30 *m.*	half ſum 112 *d.* 49 *m.*	Log. Sine	9.96461
The Sum of the 3 ſides 225 *d.* 39 *m.*	Remain. 2 *deg.* 19 *m.*	Log. Sine	8.60662
The half Sum, 112 *d.* 49 *m.*		Sum of the 4 Logarith	18.78872

The Remainer oppoſite being ſubtracted from the half ſum 2 *d.* 19 *m.* Whoſe Complement (to 180 *d.*) 28 *d.* 42 *m.* is the Azimuth from the South.

The half Sum, which is *Sc.* 75 *d.* 39 *m.* 9.39436
which doubled 75 *d.* 39 *m.*
is the Suns Azimuth 151 *d.* 18 *m.* from the North.

By the Suns Azimuth and the Magnetical Azimuth, you may find the Variation of the Compaſs.

As for Example.

Admit the Magnetical Azimuth in the Afternoon is —— S. 59 *d.* 33 *m.* Weſt.
And the Suns Azimuth is —— S. 48 *d.* 18 *m.* Weſt.

The difference is the Variation —— 11 *d.* 15 *m.*

And the Magnetical Azimuth being nearer to the North than the true Azimuth by 11 *deg.* 15 *min.* (which is one Point of the Compaſs) ſhews the Variation to be one Point Weſterly.

And ſuppoſe the Courſe by the Compaſs be Eaſt, the true Courſe is Eaſt by North.

Mr. *Boroughs* obſerved in the year 1580, the Variation 11 *d* 15 *m.* Eaſterly in *Lime-Houſe-Fields* near *London.*

The Magnetical Rumb —— 90 *d.* 00 *m.*
Subtract the Variation Weſterly —— 11 *d.* 15 *m.*
there remains the true Rumb N E 78 *d.* 45 *m.*

Mr. *Gunter* in the year 1622 in the ſame place found the Variation 6 *deg.* 15 *min.* Eaſt.

Example 2.

Suppoſe the Magnetical Azimuth be —— S. 37 *d.* 03 *m.* Weſt.
And the Suns Azimuth be —— S. 48 *d.* 18 *m.* Weſt.

Subtract the leſſer out of the greater, the difference is —— 11 *d.* 15 *m.*

And in regard the Magnetical Azimuth is farther from the North than the true Azimuth by 11 *deg.* 15 *min.* therefore the Variation is Eaſterly one Point, and conſequently all the Points ſtand 11 *deg.* 15 *min.* or one Point to the right hand of their true Places; and therefore, to make good a North Courſe, you muſt Sail by you Compaſs N by W; and an Eaſt Courſe, ſail E by N, and a South Courſe, ſail S by E; and to make good a Weſt Courſe, ſail W by S; and ſo it is to be underſtood of all other Courſes.

The year 1666 at *Briſtol*, in *Rownom* Meadows, Mr. *Philip Stainard*, my ſelf, and ſome other Friends, Maſters of Ships, took with us a *Quadrant* (deſcribed in the fifteenth Chapter of the Second Book) of 20 Inches Semidiameter, and one Needle,

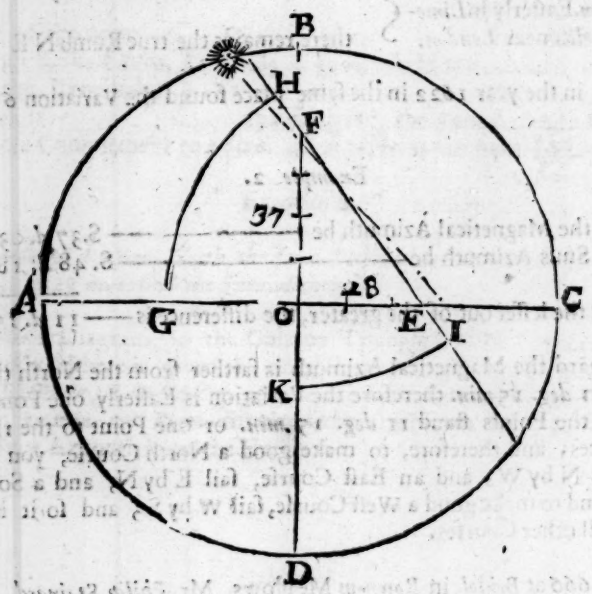
Needle, and one Azimuth Compass, (described in the First of the Fifth Book) the Needle about nine Inches long, and in the Afternoon we made these Observations following:

Suns Altitude.		Magnetic. Azimuth.		Suns Azimuth.		Variation Westerly.	
Gr.	M.	Gr.	M.	Gr.	M.	Gr.	M.
44	20	72	00	70	38	01	22
39	30	80	00	78	24	01	36
31	50	90	00	88	26	1	34
27	42	95	00	93	36	1	24
23	20	103	00	101	23	1	37

PROBL. XV.

To find the Altitude of the Sun by the Shadow of a Gnomon set Perpendicular to the Horizon by the Scale; also by Trigonometry.

WIth your Compasses on a piece of Board, describe the Circle A B C D, place it Horizontal with a Gnomon Perpendicular thereto, in the Centre O cross it with two Diameters at right Angles; then turn the Board, until the shadow be upon one of the Diameters, and at the end of the shadow make a Mark, as here at E; lay down also the length of the *Gnomon* from the Centre on the other Diameter from O to F, draw a right-Line from E to F, as E F H; then with the Chord of 60 *deg.* sweep the Arch G H upon E as a Centre; apply the distance G H on the Arch to your Line of Chords, and that will give you the Altitude of the Sun required, which in this Example is 53 *deg.*



The

The Operation by the Logarithms.

As the parts of the shadow 28 —— 1447 6

are to the parts of the *Gnomon* 37 —— 156820
So is the Radius —— 1000000

to the Tangent of 52 *deg.* 53 *min.* —— 1012104

So the Pin or *Gnomon* OF being 37 equal parts, and the shadow OE 28 such parts, the Altitude is found 52 *deg.* 53 *min.* or the *Gnomon* being 28, and the shadow 37 parts, the Altitude will be 37 *d.* 07 *m.* or the shadow being 83, the *Gnomon* or Staff 100, the Angle will be 50 *deg.* 18 *min.* the Altitude of the upper edge of the Sun or Angle HEG; from which, taking the Semi-diameter of the Sun 16 *min.* there remains 50 *d.* 2 *m.* the Altitude of the Centre of the Sun.

After this manner, if you observe the greatest Meridian-Altitude of the Sun the 11th of *June*, and 10th of *December*, you shall by the difference of them find the distance of the Tropicks; the greatest Declination of the Sun, the Elevation of the Equator, or Latitude of the Place.

As for Example at London.

Suppose the Suns Meridian-Altitude taken *June* 11, 1676	61 *d.* 59 : 30″
The Suns least Meridian-Altitude taken *December* 10	14 : 56 : 30
The diff. is the distance of the Trop. of which take the half	47 : 03 : 00
Which is the Suns greatest Dec. subtract. from the greatest Alt.	23 : 31 : 30
Leaves the Elevation of the Equator,	38 : 28 : 0
Whose Complement is the Latitude of the Place,	51 : 32 : 0

PROBL. XVI.

Having the Latitude of the place, the Suns Declination, and the Suns Altitude; to find the Hour of the Day.

THE Rule by the Logarithms is thus; Add the Complement of the Suns Altitude, and the Complement of the Suns Declination, (or Distance of the Sun from the Elevated Pole) and the Complement of your Latitude together, and from half the Sum thereof subtract the Complement of the Altitude, and note the difference.

Thus in our Latitude of *Bristol* 51 *deg.* 28 *min.* the Declination of the Sun, being 20 *deg.* 30 *min.* Northward, and the Altitude 51 *deg.* 12 *min.* I find the hour from the Meridian, as follows:

Altitude of the Sun	51 *d.* 12. the Compl. 38 *d.* 48	As the Radius ——	10
Declination North	20 : 30		
The dist. from the Pole	69 : 30.	To Sine of the Polar distance —	997359
Latitude North	51 : 28. the Compl. 38 : 32	so is the Sine Compl. of Lat. —	979447
The sum of all three	146 : 50	to a fourth Sine ——	976606
The half Sum ——	73 : 25	As the 4 Sine is to the sine of half sum	908155
The difference ——	34 : 37	so is the Sine of the difference ——	975441
			1973596
To a seventh Sine, to which add the Radius ——			1996990
And take the half ——			998495

Which is the Sine Compl. of 15 *d.* 05 *m.*
Which doubled is 30 *d.* 00 *m.* or 2 hours from Noon.

PROBL. XVII.

Having the Azimuth of the Sun, the Altitude and the Declination; to find the Hour of the Day.

Example.

THe Declination 20 *deg.* 30 *m.* No. the Altitude 51 *deg.* 12 *min.* the Azimuth from the North 131 *deg.* 42 *m.* to find the hour from Noon.

The Operation by Logaritbms.

As the Co-Sine of the Declination 69 *deg.* 30 *min.*	597159
is to the Sine of the Azimuth 131 *deg.* 42 *min.*	987311
So is the Co-Sine of the Altitude 38 *deg.* 48 *min.*	979699
to the Sine of the Hour 29 *deg.* 58 *min.*	1967010
Which is 1 *hour.* 59 *min.* 52 ″.	969851

PROBL. XVIII.

How to find the Right-Aſcenſion, and the Declination of a Star; having the Longitude and Latitude thereof.

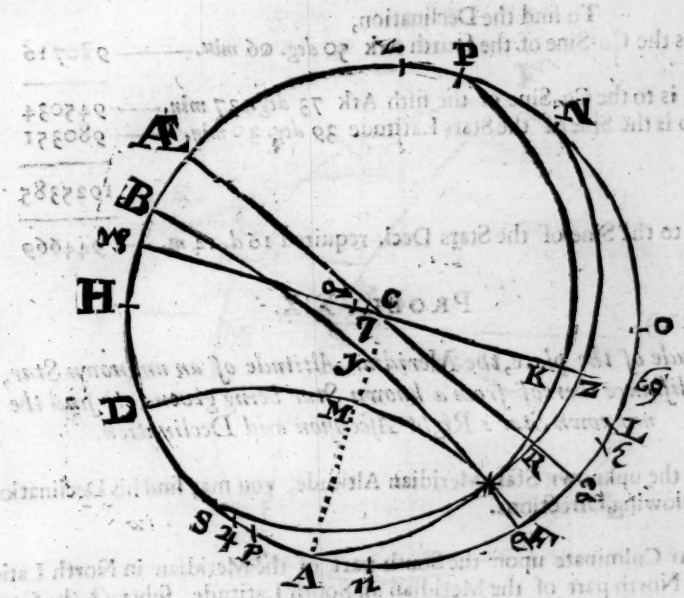
Example.

THe mouth of *Sirius*, whoſe Longitude is 9 *deg.* 32 *min.* 69 ″ Latitude 39 *deg.* 30 *min.* South, to find the right Aſcenſion and Declination.

To Project the Sphere *Stereographically*, draw the Meridian with a Chord of 60 *deg.* you may mark the Horizon H O, and Vertical Z N; then ſet the Latitude 51 *deg.* 28 *min.* from O to N, from H to S, and from N to Q, and from Z to Æ; and draw the Equinoctial-Line Æ C Q, then take the diſtance of the Pole of the Ecliptick, from the Pole of the World 23 *deg.* 31 *min.* and prick it from N to P, from Æ to ♈, from S to A, and from Q to ♎; then draw the Ecliptick-Line ♈, C, ♎, on which you muſt put the Longitude or diſtance of the Star, from the next Equinoctial Point, as in this Example; The Star in the Mouth of the great Dog or *Sirius*, his Longitude is 9 *deg.* 32 *min.* of *Cancer*; and his Latitude is 39 *deg.* 30 *m.* South, take 9 *deg.* 32 *min.* out of 90 *deg.* the Remain is 80 *deg.* 28 *min.* the diſtance of the Star from the next Equinoctial Point C, prick that from C to K on the Ecliptick, and draw the Circle of Longitude P K S, then prick the Latitude 39 *deg.* 30 *m.* from ♈ to D, and from ♎ to F from the Chords; then take the ſame from the half-Tangents, and prick it from C to M, and draw the Circle of Latitude of the Star parallel to the Ecliptick, as D M F, and where this Parallel cuts the Circle of Longitude, as at ✳, that is, the place of the Star; then draw the Meridian Circle from the North Pole through ✳ to the South-Pole, and it cuts the Equinoctial in R; meaſure C R on the Line of half-Tangents, and it gives 82 *deg.* 31 *min.* the Complement to 180 *deg.* is 97 *deg.* 39 *min.* the Right-Aſcenſion deſired.

Now to find the Declination of the Star; lay a Ruler over P and the Ecliptick, at K, and it will cut the Arch in L; take a Chord of 90 *d.* and prick it from L to P; lay a Ruler over *p* and P, and it will cut the Ecliptick in ♉; lay the Ruler over ♉, and ✳, and it cuts the Lamb in *e*; meaſure Q *e* on the Line of Chords, and it is 16 *d.* 14 *m.* the Stars Declination required.

The



The Operation by Logarithms.

Take 9 *deg.* 32 *min.* the Longitude of the Star, out of 90 *deg.* there remains 80 *deg.* 28 *min.* his distance from the next Equinoctial Point; which being known, the first Operation is,

As the Radius	10
is to the Sine of the Stars Longit. from the next Equ. Point 80 *d.* 28	999396
So is the Co-Tangent of the Stars Latitude 39 *deg.* 30 *min.*	1008389
to the Tangent of the fourth Ark 50 *deg.* 06 *min.*	1007785

Compare this fourth Ark with the distance betwixt the Poles of the Ecliptick, and the Poles of the World 23 *deg.* 31 *m.* if the Longitude and Latitude of the Star be alike, as in the North Sines, ♈ ♉ ♊ ♋ ♌ ♍, and the Latitude on the North-side the Ecliptick; or if the Longitude be among the Southern Sines, as ♎ ♏ ♐ ♑ ♒ ♓, and the Latitude Southward; then shall the difference between the fourth Ark found, and the distance of the Poles be your fifth Ark.

But if the Longitude and Latitude shall be unlike, as it is in this Example; the Longitude in a Northern Sine, and the Latitude South; or the Longitude in a Southern Sine, and the Latitude North; then add this fourth Ark found, to the distance of both Poles 23 *deg.* 31 *min.* the sum of both shall be the fifth Ark.

Then say,

As the *Sine* of the Fourth Ark 50 *deg.* 06 *m.*	988489
is to the *Sine* of the Fifth Ark 73 *deg.* 37 *m.*	998200
So is the Tan. of the *Stars* Long. from the next Equin. Point 80 *d.* 28 *m.*	4077484
to the Tan. of the *Stars* Right-Ascen. from the next Eq. Point 82 *d.* 21 *m.*	2075684
Which subtract. from 180 leaves 97 *d.* 39 *m.* the Right-As. of *Sirius* required,	1087195

To find the Declination,

As the Co-Sine of the fourth Ark 50 *deg.* 06 *min.* —— 980716

is to the Co-Sine of the fifth Ark 73 *deg.* 37 *min.* —— 945034
So is the Sine of the Stars Latitude 39 *deg.* 30 *min.* —— 980351

1925385

to the Sine of the Stars Decl. required 16 *d.* 14 *m.* —— 944669

PROBL. XIX.

The Latitude of the place, the Meridian Altitude of an unknown Star, and the diſtance thereof from a known Star being given; to find the unknown Star's Right Aſcenſion and Declination.

FIrſt, by the unknown Stars Meridian Altitude, you may find his Declination, by the following Directions.

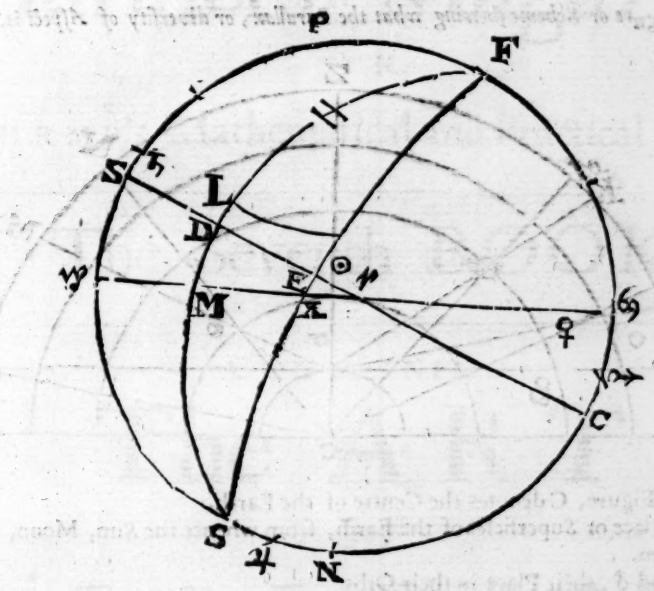
If the Star Culminate upon the South part of the Meridian in North Latitude, or upon the North part of the Meridian in South Latitude, ſubtract the Complement of the Latitude of the place, from the Stars Meridian Altitude, the Remainer is the Stars Declination, Northerly in North Latitude, and Southerly in South; but if the Complement of the Latitude exceed the Meridian Altitude, ſubtract the Meridian Altitude from the Complement of the Latitude, the Remainer is the Stars Declination, Southerly in North Latitude, and Northerly in South: But if the Star Culminate upon the North part of the Meridian in North Latitude, or upon the South part of the Meridian in South Latitude, above the Elevated Pole, then ſubtract the Meridian Altitude from 180 *deg.* and from the Remainer ſubtract the Complement of the Latitude, the laſt Remainer is Declination, Northerly in North Latitude, and Southerly in South; but if the Star Culminate under the Elevated Pole; to the Meridian Altitude add the Complement of the Latitude, the ſum is the Declination, Northerly in North Latitude, and Southerly in South.

Example.

In the year 1577. Noble *Tycho Brahe*, found the Declination of the Northern Star in the breaſt of *Pegaſus* to be 22 *deg.* 26 *min.* Northerly, and its diſtance from the Eagles heart 45 *deg.* 31 *min.* whereby the right Aſcenſion may be found, as follows:

In the Oblique Triangle F O L in the following Scheme, there is given the three ſides F L the Complement of the Declination of the Eagles heart 82 *deg.* 08 *min.* F O the Complement of the Declination of *Pegaſus* breaſt 67 *deg.* 34 *min.* and L O the diſtance between them 45 *deg.* 31 *min.* to find the Angle L F O, the difference of the Right Aſcenſion of the two Stars.

The



The Operation by the Logarithm.

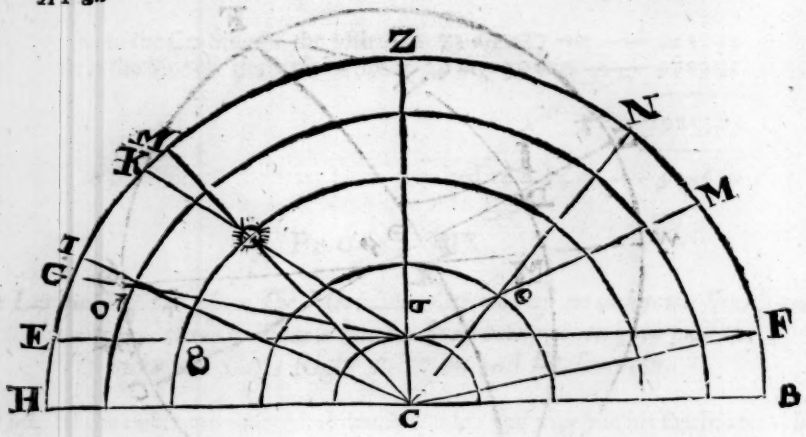
The containing ſides	F L 82 *d* 08 *m.*			*Sine* Co-Arith.	0.00411
	F O 67 34			*Sine* Co-Arith.	0.03418
The oppoſite ſide	L O 45 31	half ſum	97. 36	*Sine* Log.	9.99618
		Remain.	52. 05	*Sine* Log.	989702
Sum of the three ſides	195 13			*Sum*	19.93148
The half ſum	97 36				
		Sine Compl.	22 *d.* 28 *m.*	Half *Sum*	9.96574
The Remainer	52 05	Doubled	22 28		
	Gives the Angle L F O		44 56		

Which is the difference of the Right Aſcenſion of the two *Stars*, and added to the Right Aſcenſion of the Eagles heart 292 *deg.* 35 *min.* the ſum 337 *deg.* 31 *min.* is the Right Aſcenſion of the *Star* in *Pegaſus* breaſt, which was required.

Of the Parallax of Altitude of the Sun, Moon, or Stars.

THe true Altitude of the *Sun*, Moon, or *Stars*, ought to be obſerved in the Centre of the Earth, (if poſſible) whereto the Tables are conformed; but becauſe we dwell upon the *Superficies* of the Earth above 5000 Engliſh Miles from the Center of the Earth; therefore the Planets ſeem lower to us than indeed they be; and therefore to repreſent the true place of the *Sun*, Moon, or *Stars*, you muſt draw a Right-Line from the Centre of the Earth, through the Centre of the *Sun*, Moon, or *Star*; but the apparent place is determined by a Line drawn from the Eye, through the Centre of the *Star*.

A Figure or Scheme shewing what the Parallax, or diversity of Aspect is.



In this Figure, C denotes the Centre of the Earth.
D the Place or Superficies of the Earth, from whence the Sun, Moon, or Star is seen.
☾ ☉ and ♂, their Place in their Orbs.
C ♂ I, C ☉ M, C ☾ N, the Lines of their true Place.
D ♂ G, D ☉ K, D ☾ M, the Lines of their visible or apparent Places.

Hence the Angle made by the Intersection of the said two Lines through the Body of the Planet, is the Angle of Parallax, that is to say, in ♂ the Angle C ♂ D, which is equal to the Angle I ♂ G, in the ☉ the Angle of Parallax, is the Angle C ☉ D; and lastly, in the Moon it is the Angle C ☾ D, or N ☾ M.

By this it is manifest, the nearer a Star is to the Centre of the Earth, and the lesser the Altitude above the Horizon, the greater is the Parallax; and hence it is, that the Orbit of the Moon being nearest to the Earth, her Parallax is greatest, and most perceptible, because the Semidiameter of the Earth bears a sensible proportion to the Semidiameter of the Moons Orbit, though it be very little, or nothing at all in comparison of the Orbs of ♄ ♃, and the fixed Stars, which is caused by the vast distance which is between them.

The End of the Sixth Book.

THE

Mariners Magazine,

OR,

STURMY's Mathematical and Practical ARTS.

The Seventh BOOK.

CONTAINING

The ART OF DIALLING BY THE Gnomical Scale,

AS ALSO BY

CALCULATION.

SHEWING

The making of all DIALS, within Doors or without, upon any Wall, Cieling, or Floors, whereſoever the Direct or Reflected Beams of the Sun may come.

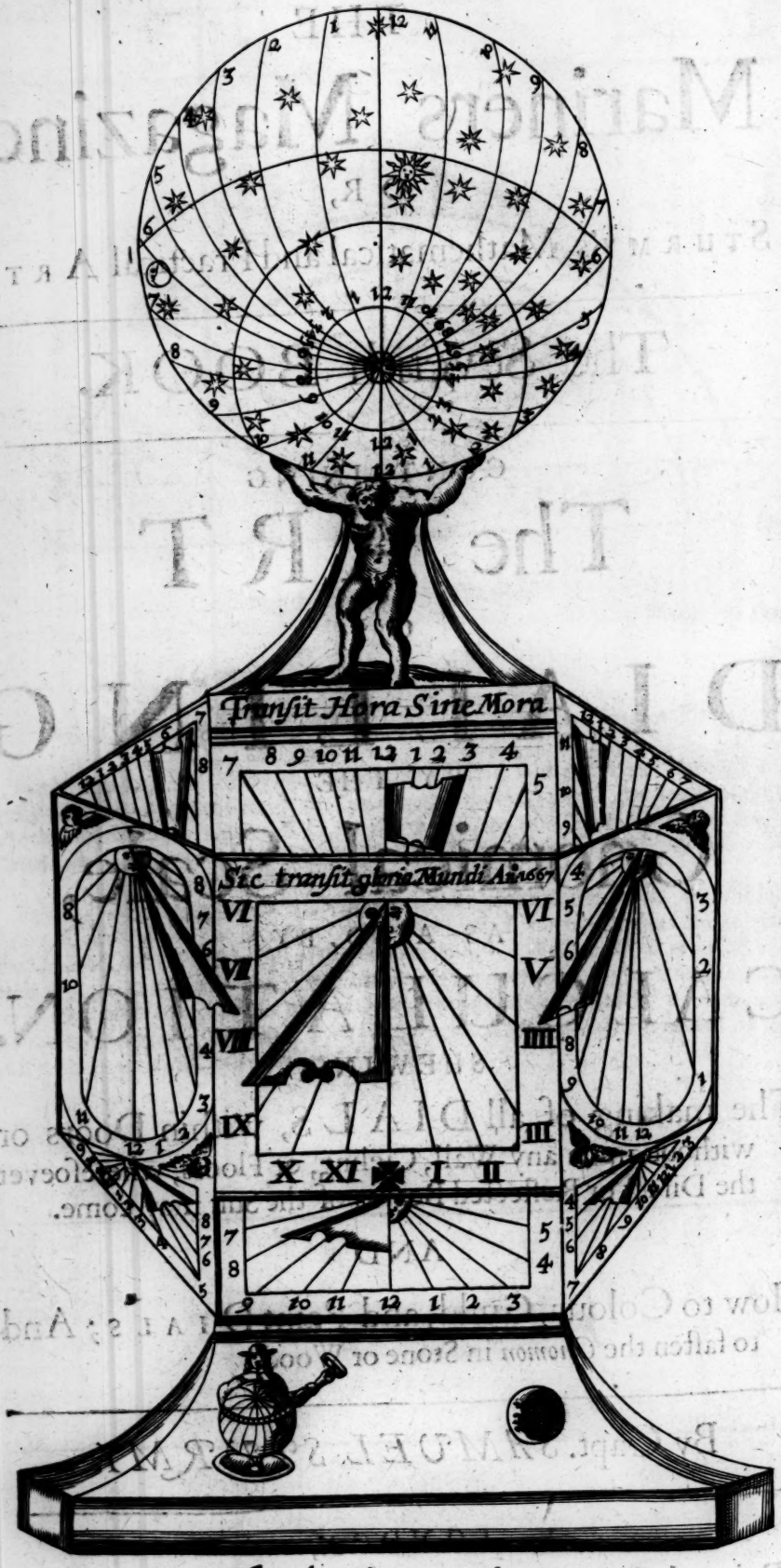
AND

How to Colour, Guild, and Paint DIALS; And to faſten the *Gnomon* in Stone or Wood.

By Capt. *SAMUEL STURMY.*

LONDON,

Printed by *M. Clark*, *Anno Dom.* 1678.



Horologium vitæ.

Latus ad occasum nunquam rediturus ad ortum
Vivo hodie, moriar cras, heri natus eram

To my much Honoured Friend

Iſaac Morgan Eſq;

Collector of His Majeſties Cuſtoms in the Port of *Briſtol.*

SIR,

NOt *to inform your Judgment in any thing concerning the Subject Matter of theſe my poor Labours (your Wiſdom and approved Knowledge in all Learning being ſo general, that I can add nothing unto it) but to inform the World how much I honour you and your Vertues, and by how many Obligations I ſtand engaged to you for the many ſignal Favours you have vouchſafed me ſince the time I came firſt into this Port; I dedicate this Part of my Book, as the proper Part of the fruits of my ſpare time, in twenty ſeven* Dials, *unto you preſented as an unworthy* New-years-gift; *and that* Dial-piece *being the Subject of the whole Art of* Dialling, *I will name the* Dials, *that I may charge you to Patronage no more than you had;* viz. *Eight* Verticals *and* Decliners, *Eight* Recliners *and* Incliners, *and Eight* Decliners, Recliners, *and* Incliners, *a* Globe *with two* Pole-Dials, *and one* Shadow-Dial, *made on a piece of* Free-ſtone, *as is ſeen in the Frontiſpiece, the* Gnomons *faſtned by me, and likewiſe Painted and Guilded, which is well known by you, and many others: And being deſired by ſome Friends that ſaw my way, and this Piece of* Dialling, *to Print it, by*

their Importunity, according to the best of my Judgment, I have so done; and if any way profitably, then according to my own desire. As it is, I have made bold to make choice of you for the Patronage thereof, that it may gain the more Credit by your Protection; And if any shall be offended at this Work, my Device shall be a Dial *with this* Motto, ASPICIO UT ASPICIAR; *only to all Favourers of* ART *I am* direct, erect, plain, *as I am to you, and desire to be,*

SIR,

Your humble and affectionate

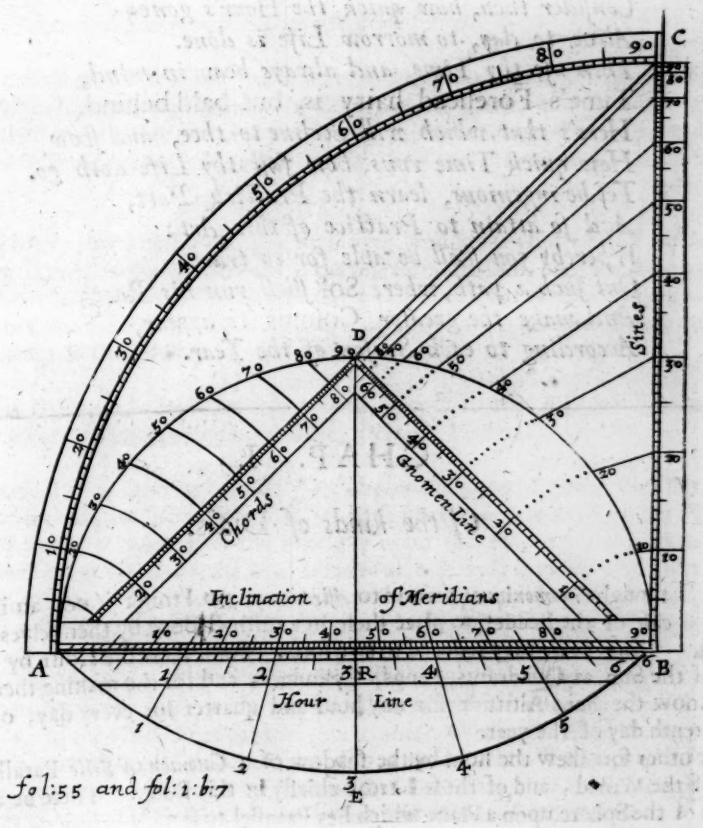
Servant to be commanded,

St. Georges the Pil,
29 Aug. 1687.

SAMUEL STURMY.

THE Art of Dialling.

The FUNDAMENTAL DIAGRAM *of the* DIALLING SCALE.



fol:55 and fol:1:b:7

THis *Diagram* of the *Gnomical Scale* I have described, *Book* 2. *Chap.* 3. to which I refer you.

I shall only enumerate the Lines on the Scale.

There are six Lines on this Instrument.

1. A Line of Chords.

2. The *Gnomon* Line, or Line of Latitudes.
3. A Line of ſix Hours, for drawing the Hour-lines in any Dial, divided into every 10 Minutes.
4. A line of the Inclination of Meridians.
5, and 6. Two Lines for the inlarging the Hour-Lines: The greater is marked with +; the leſſer is marked with ——, called the greater and leſſer Pole for diſtinction ſake, and theſe Lines are divided into every 10 Minutes.

THE ARGUMENT.

READer, read this; for I dare this defend,
Thy poſting Life on Dials *doth depend.*
Conſider thou, how quick the Hour's gone;
Alive to day, to morrow Life is done.
Then uſe thy Time, and always bear in mind,
Time's Forehead hairy is, but bald behind.
Here's that which will decline to thee, and ſhow
How quick Time runs, how faſt thy Life doth go.
Yet be ingenious, learn the Practick Part,
And ſo attain to Practice of this Art:
Whereby you ſhall be able for to trace
Out ſuch a path, where Sol *ſhall run his Race;*
And make the greater Cosmus *to appear,*
According to each Seaſon of the Year.

CHAP. I.

Of the kinds of Dials.

ALthough *Gnomoniques* pertain to *Aſtronomy*, yet I think it not amiſs for the eaſe of the Reader, to place theſe in a diſtinct Book by themſelves.

Sun-Dials may reduced to two ſorts. Some ſhew the Hour by the Altitude of the Sun, as Quadrants, Rings, Cylinders; and for the making thereof, you muſt know the Suns Altitude for any hour and quarter for every day, or at leaſt every tenth day of the year.

The other ſort ſhew the hour by the ſhadow of a *Gnomon* or *Stile*-Parallel to the *Axis* of the World, and of thoſe I treat chiefly in this Book. Theſe be all Projections of the Sphere, upon a Plane which lies Parallel to ſome *Horizon* on the Earth; And if upon ſuch a Plane the *Meridians* be projected, they ſhall ſuffice to ſhew the Hour, without projecting the other Circles, as the *Ecliptick*, the *Æquator* with his Parallels of Declination, the *Horizon* with his *Almicanters* and *Azimuths*, which are ſometimes drawn upon *Dials* more for Ornament than Neceſſity.

CHAP. II.

Theorems premiſed.

FOr the better underſtanding of the Art of Dialling theſe *Theorems* ſhould be known.

I. That every Plane whereupon any *Dial* is drawn, is part of the Plane of a great Circle of the Sphere, which Circle is an *Horizon* to ſome Country or other; That the Center of the *Dial*, repreſenteth the Center of the Earth, and the *Gnomon* which caſteth the Shade, repreſenteth the *Axis*, and ought to point directly to the two Poles.

II. That theſe *Dial* Planes are not Mathematically in the very Planes of great Circles; for then they ſhould have their Centers in the Center of the Earth, from which they are removed almoſt 4000 miles; and yet we may ſay they lye in the Planes of thoſe Circles, becauſe the Semidiameter of the Earth beareth ſo ſmall proportion to the Suns diſtance therefrom, that the whole Earth may be taken for one Point or Center, without any ſenſible Error.

III. That as all great Circles of the Sphere, ſo every *Dial* Plane hath his *Axis*, which is a ſtraight Line paſſing through the Center of the Plane, and making Right Angles with it; and in the *Axis* are the two Poles of the Plane, whereof that above our *Horizon* is called the *Pole Zenith*, and the other the *Pole Nadir* of the *Dial*.

IV. That every Plane hath two Faces or Sides: And look what reſpect or ſituation the North Pole of the World hath to the one ſide, the ſame hath the South Pole to the other; and theſe two Sides will receive all the Hours of the longeſt day. So that what one Side wanteth, the other Side ſhall have; and the one is deſcribed in all things as the other.

V. That as *Horizons*, ſo *Dial* Planes are with reſpect to the *Æquator* divided into firſt, *Parallel*; ſecondly, *Right*; thirdly, *Oblique* Planes.

VI. A Parallel or Polar Plane maketh no *Angles* with the *Æquator*, but lies in the Plane of it, or parallel to it; that is, hath the *Gnomon* erected on the Plane at Right Angles, as the *Axis* of the World is upon the Plane of the *Æquator*: becauſe the *Axis* and *Poles* of the *Dial* are here all one with the *Axis* and Poles of the World, and the Hour-lines here meet all at the Center, making equal Angles, and dividing the *Dial* Circle into 24 equal parts, as the *Meridians* do the *Æquator*.

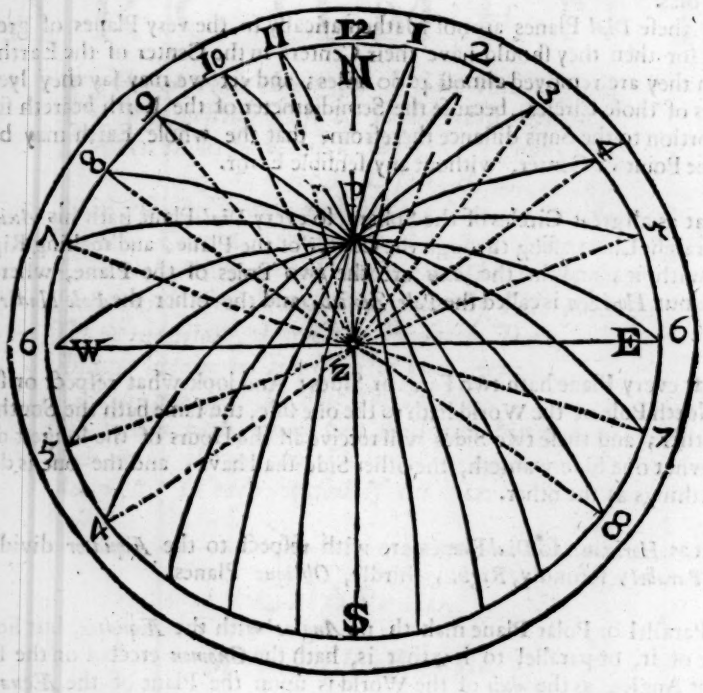
VII. A Right *Horizon* or *Dial* Plane cutteth the *Æquator* at Right Angles, and ſo paſſeth through the *Poles* of the World, that it hath the *Gnomon* parallel to the Plane, and ſo the Hour-lines parallel one to another; becauſe their Planes, though infinitely extended, will never cut the *Axis* of the World: Yet have thoſe *Dials* a Center, though not from the meeting of the Hour-lines, but that through which the *Axis* of the *Dial* Circle paſſeth, cutting the Plane at Right Angles.

VIII. An Oblique *Horizon* or *Dial* Plane cutteth the *Æquator* at Oblique Angles; and hath for its *Gnomon* the ſide of a Triangle, whoſe Angles vary according to the more or leſs Obliquity of the ſaid *Horizon*: and the *Gnomon* ſhall always make an Angle with the Plane, of ſo many Degrees as the *Axis* of the World maketh with the Plane, or as either of the *Poles* of the World is elevated above the Plane.

IX. Every

IX. Every Oblique *Horizon* is divided by the *Meridians* or Hour-circles of the Sphere into 24 unequal parts; which parts are always leſſer, as they are nearer to the Meridian of that Horizon or Plane; and greater, as they are farther off: and on both ſides of the Meridian of the Plane, the Hour-circles which are equally diſtant in time, are alſo equally diſtant in ſpace. Whence it is, that the diviſions of one Quadrant of your Dial Plane being known, the diviſions of the whole Circle are likewiſe known.

X. The Hour-lines in an Oblique Dial, are the Sections of the Planes of the Hour-circles of the Sphere, with the Dial Plane: And becauſe the Planes of great Circles do always cut one another in Halves by Diameters, which are ſtraight Lines



paſſing through the common Center; therefore Lines drawn from the Center of the Dial, to the Interſections of the Hour-circles with the great Circles of the Plane, ſhall be thoſe Sections, and the Hour-lines of the Dial.

XI. Every Dial Plane being an Horizon to ſome place in the Earth (as was ſaid, *Theorem* I.) hath his proper Meridian, which is the Meridian paſſing through the Poles of the Plane, and making Right Angles with the Plane. If the Poles of the Dial Plane lie in the Meridian of the Place, then is the Meridian of the Plane all one with the Meridian of the Place, and the Gnomon or Style ſhall ſtand erected upon the Noon-line, or Line of 12 a Clock, as in all direct Dials. But if the Plane decline, then ſhall the Subſtyle Line, or Line which the Gnomon ſtandeth upon (which is the Meridian of the Plane) vary from the Line which is the Meridian of the Place; and this Variation ſhall be Eaſt, if the Declination of the Plane be Weſt: And contrarily, becauſe the Viſual lines, by which the Sphere is projected on Dial Planes, do, like the Beam in a Burning-glaſs, interſect or croſs one another in a certain Point of the Gnomon (to be aſſigned at pleaſure) and called the *Nodus*, and ſo do all ſhadow themſelves on the Dial Plane, beyond the *Nodus*, the contrary way.

XII. Dials

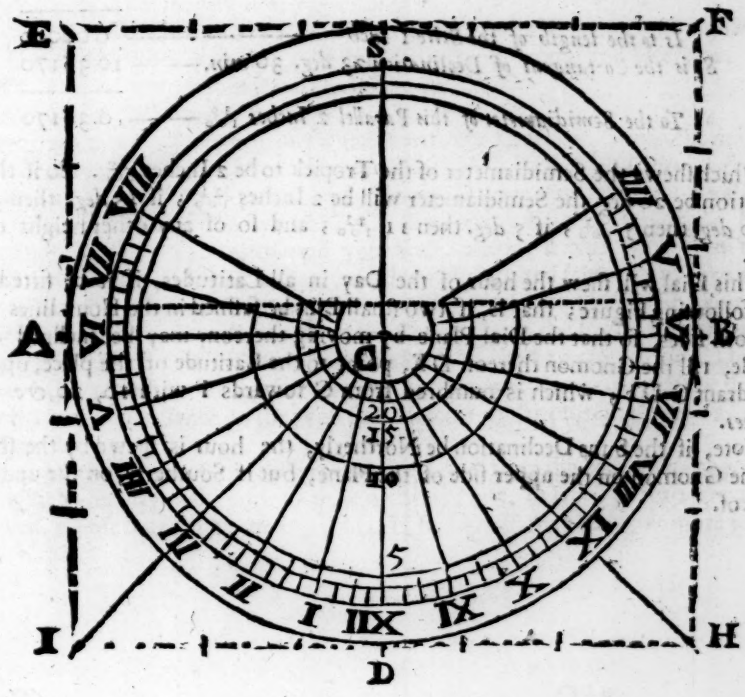
XII. Dials are moſt aptly denominated from that part of the Sphere where their Poles lie, though ſome Authors have choſen to denominate them from the Circles in which their Planes lie; as the Dial Plane which lieth in the Æquinoctial, (or Parallel to it) is called by many an Æquinoctial Plane; but I concur with thoſe who would rather call it a Polar Plane, becauſe the Poles thereof are in the Poles of the World.

CHAP. III.

How to make a Polar Dial, commonly called an Equinoctial Dial, and how to place it.

THe Plane of the Polar Dial lieth in the Æquinoctial, where the 12 Meridians or Hour-circles divide both the Æquinoctial and this Plane into 24 Hours or equal parts; the Gnomon ſtands upon the Center at Right Angles with the Plane.

Firſt, draw the Horizontal Line A B, and croſs the ſame at Right Angles with the Line C D: Now on the Center at C, with the Chord of 60 Degrees, deſcribe the Circle A D B S, and about it make the Square E F H I; then take out of the Line of Hours one Hour, and lay it from each corner, as E, F, H, I, both ways: Alſo do the like with two Hours, and from the Center at G draw Lines to thoſe Hour-points: So ſhall you have the Hour-lines in the Æquinoctial Dial, C D being the Meridian or 12 a clock Line, and A B the Eaſt and Weſt Line, being for 6 in the Morning at B, and 6 in the Afternoon at A, and ſo number the reſt of the Hours in order: You need draw no more hours than from 4 in the morning unto 8 at night, for this Latitude of *Briſtol*, being near 51 *deg.* 30 *min.*



For

For the Gnomon or Stile, you must have a straight Pin or Wire set upright in the Center, of such length as you see convenient; but if you will have it of such a length, as to shew the Suns Declination, you may find it by the following direction.

To find the length of the Stile, and Semidiameters of the Parallels of Declination by Trigonometry.

IF it were required to proportion the Stile to the Plane, suppose the Semidiameter of the greatest Parallel upon the Plane were but 6 Inches, and the Parallel should be of 5 *deg.* of Declination, the Rule is.

As the Tangent of 45 *deg.*	10.00000
Is to the Tangent of the Parallel of Declination 5 *deg.*	8.94195
So is the Semidiameter of the Plane 6 *inches* C 5	0.77815
To the length of the Stile 52 *parts*	1.72010

Which shews that the length of the Stile must be $\frac{52}{100}$ parts of an Inch.

By the length of the Stile, to find the Semidiameter of the Parallel of Declination.

SUppose the length of the Stile above the Plane to be 1 Inch, and you were to find the Semidiameter of the Tropick, whose Declination is known to be 23 *d.* 30 *m.* the Rule for this or any other Parallel of Declination,

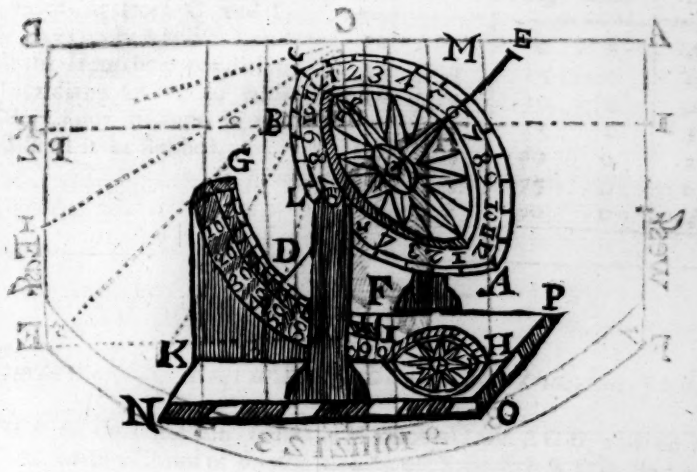
As the Tangent of 45 *deg.*	10.00000
Is to the length of the Stile 1 *Inch*	0.00000
So is the Co-tangent of Declination 23 *deg.* 30 *min.*	10.36170
To the Semidiameter of this Parallel 2 *Inches* $\frac{30}{100}$	0.36170

Which shews the Semidiameter of the Tropick to be 2 Inches $\frac{30}{100}$. So if the Declination be 20 *deg.* the Semidiameter will be 2 Inches $\frac{21}{100}$; if 15 *deg.* then 3 $\frac{11}{100}$; if 10 *deg.* then 5 $\frac{92}{100}$; if 5 *deg.* then 11 $\frac{42}{100}$; and so of any other height of the Stile.

This Dial will shew the hour of the Day in all Latitudes, if it be fitted as in the following Figure; that is, if two small Pins be fastned in the Hour-lines of Six on both sides, so that the Dial Plane by moving thereon, may be inclined to any Angle, till the Gnomon thereof D E, point to the Latitude of the place, upon the Quadrant G D F; which is numbred from G towards F with 10, 20, *&c.* to 90 *degrees.*

Note, if the Suns Declination be Northerly, the hour is shewn by the shadow of the Gnomon on the upper side of the Plane, but if Southerly, on the under side thereof.





CHAP. IV.

How to make the direct Æquinoctial Dial, or Polar Plane.

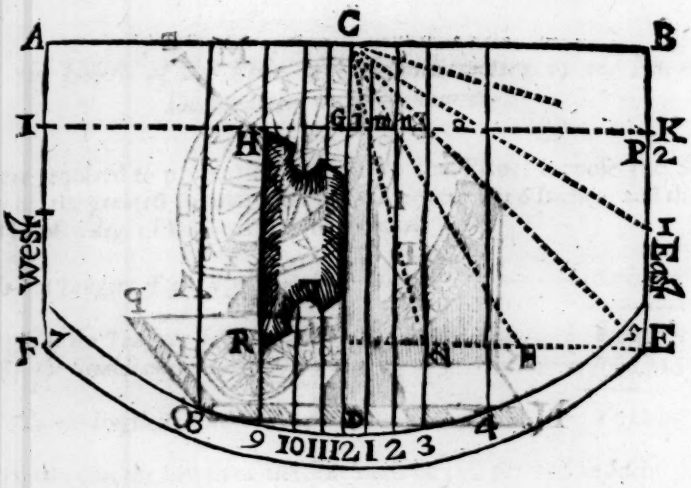
THe Æquinoctial Dial we call that which hath his Poles in the Æquinoctial Circle, of which there be three kinds:

1. The direct or South Æquinoctial Dial, which faceth the Meridian directly, having his Poles in the Intersections of the Æquinoctial and Meridian.
2. The East or West Æquinoctial Dial there are direct.
3. A declining Æquinoctial Plane.

How to make the first of these, draw the Horizontal Line A B, and in the midst at C raise the Perpendicular C D, which is the Meridian or 12 a clock Line. Let C D be equal to a Chord of 60 degrees, and through D draw the Line F E, parallel to A B; make also D E and C B equal to D C, so have you a Square C D E B. Now take one hour with your Compasses off your Scale, and lay it both ways from E towards B and D, as E 1, E 1, E 2, E 2, and draw the pricked Lines from C to these Points. Then drawing a Line through G, parallel to the Horizon, as I K, you shall find it cut the former Lines drawn from the Center C, in the Poins I, m, n, o, p: through which Points, if you draw Parallel-Lines to the 12 a clock Line C D, you shall have all the afternoon hours as far as 5, and the morning hours must be drawn in like manner and distance on the West side, from 7 in the morning unto 12, as in the Figure following.

Note, that the height of the Stile is always 3 hours from the Meridian, as you see H G, which you may make with Copper or Brass Plate, or Iron, in form as you see shadowed, whose breadth on the top is here H R, which may be made more or less as you please.

This Dial will ſerve in any Latitude, if the Plane be placed parallel to the Plane of the hour of 6, and ſo parallel to the Axis of the World.



How to find the Height of the Stile, and the Hour-diſtances from the Meridian by the Logarithms.

Suppoſe the length of the Horizontal Line A B or F E be 12 Inches, and that it were required to put on all the Hours from 7 in the Morning to 5 in the Evening; here we have for 5 hours, 6 inches on either ſide of the Meridian, wherefore allowing 15 degrees for an hour, to find the height of the Stile proceed thus:

As the Tangent 75 *deg.* (*for* 5 *hours*)	1057195
Is to the diſtance from the Meridian 6 *inches*	077815
So is the Tangent of 45 *Degrees*	1000000
To the height of the Stile 1 *Inch* $\frac{62}{100}$	020620

And likewiſe the diſtance of the hours of 9 and 3 from the Meridian will be 1 inch and $\frac{62}{100}$ parts.

To find the Hour-diſtances from the Subſtile or hour of 12.

Having found the length of the Stile to be 1 inch $\frac{62}{100}$ parts, we find the reſt as follows:

As for example, for the hours of 11 *and* 1 *ſay,*

As the Tangent of 45 *deg.*	1000000
Is to the Tangent of the Hour from the Meridian 15 *deg.*	942805
So is the height of the Stile 1 $\frac{62}{100}$ *inches*	020620
To the diſtance from the Meridian or Subſtile $\frac{43}{100}$ *inch*	163425

Then

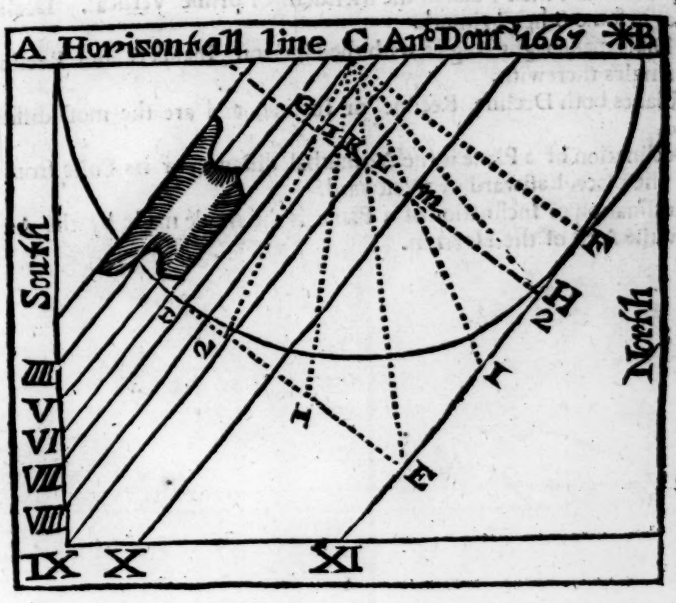
Then the Hour distance of 1 and of 11 taken from a Scale of Inches divided into 100 parts, and prick it from C and D both ways on B A and E F, and draw the Hour-lines parallel to the Meridian; and so do with the other hour distances in the Table until it be finished.

Hours		An. Po. deg.	min.	Tang. In.	par.
12		0	0	0	0
11	1	15	0	0	43
10	2	30	0	0	93
9	3	45	0	1	61
8	4	60	0	2	79
7	5	75	0	6	0
6	6	90	0	*Infinit.*	

CHAP. V.

How to make the East or West Æquinoctial Dial, Lat. 51 d. 30 m.

First, for the East Plain, draw the Horizontal Line A C B, and on the Center C, with a Chord of 60 *deg.* describe the Semicircle A D B, and prick of the Chord of 51 *deg.* ½ from A to D, and the Chord of 38 *deg.* ½ from B to F, and draw the Lines C D and C F, then making F E and D E equal to C D or C F, finish the Square C D E F. And from the corner at E, lay down both ways towards D and F the hours of 1 and 2, from whence draw Lines to the Center C: Next make choice of the height of your Stile, which lay down from C to G on the 6 hour Line, drawing from the Point G a Line perpendicular to the Line of 6, or parallel to C F, as G H, which cuts the former Lines in the Points I K L M H; through which Points drawing Lines parallel to the hour of 6, you shall have the morning hours from 6 to 11; and the hours before 6, as 5 and 4 as are of the same distance from Six as 7 and 8.



How to make the West Æquinoctial Dial.

THe West Plane is Delineated in all respects like the East, only when you have described the Semicircle A D B, you must lay the Chord of the Latitude 51 *deg.* ½ from B which will give the Point D, and the Chord of 38 *deg.* ½ the Complement of the Latitude, from A for the Point F; then proceed as before in the East Plane, numbring the Hourlines with the hours of 1, 2, 3, 4, 5, 6, 7, and 8 Afternoon.

The Stiles height and hour distances, are found by the Logarithm, as in the South Æquinoctial Plane, reckoning your hours from 6, which is the Substile.

For Example:

Suppose the distance C F for the hour of 11 on the East Plane, were 37 Inches $\frac{11}{100}$; The Perpendicular height of the Stile is 1 Inch, the distance G m is 1 inch $\frac{11}{100}$, and G l 1 inch, G k $\frac{11}{100}$, and G i $\frac{12}{100}$ of an inch.

CHAP. VI.

Of the kinds of Oblique Dials.

WHat an Oblique Dial is, and why it hath been so called, hath been shewed, *Chap.* 2.

They be { Direct, or Declining } { Either of which may be } { Erect, Recline, or Incline } to the Horizon.

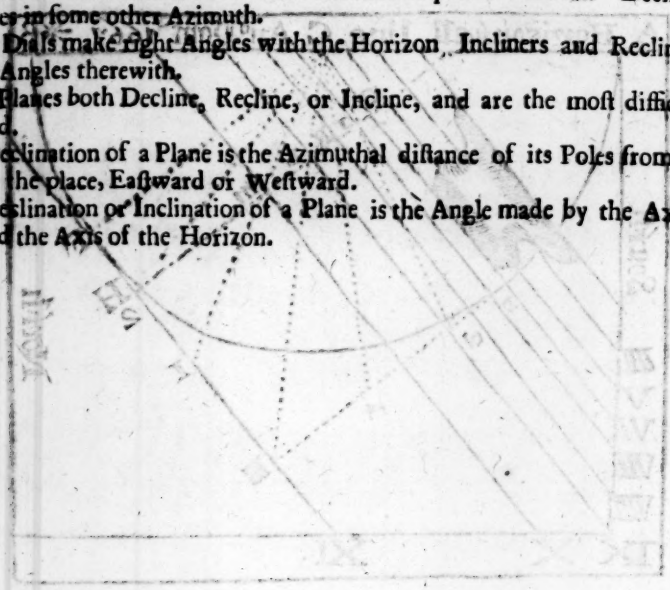
Direct Dials have their Poles in the Meridian or prime Vertical. Decliners have their Poles in some other Azimuth.

Erect Dials make right Angles with the Horizon, Incliners and Recliners make Oblique Angles therewith.

Some Planes both Decline, Recline, or Incline, and are the most difficult to be delineated.

The Declination of a Plane is the Azimuthal distance of its Poles from the Meridian of the place, Eastward or Westward.

The Reclination or Inclination of a Plane is the Angle made by the Axis of the Plane, and the Axis of the Horizon.



CHAP.

CHAP. VII.

How to make the Vertical Dial, commonly called the Horizontal Dial.

DRaw first the Horizontal-line A B, which is the Hour-line of 6; then take the Latitude of 51 *deg.* 30 *min.* from the Gnomon-line, and lay it down both ways from the Center C to A and B; then take the whole line of 6 hours, fixing one leg of your Compasses on A, describe a little Arch towards D; do the like from the Point B, crossing the former Arch at D; so draw the Line A D and B D. Now upon these Lines you must place the 6 hours on the Scale from D unto A, and also from D unto B, that is the hours of 1, 2, 3, 4, 5, from whence drawing Lines from the Center C, you shall have the hours as you see numbred from 4 in the morning until 8 in the afternoon, which suffice for this Latitude.

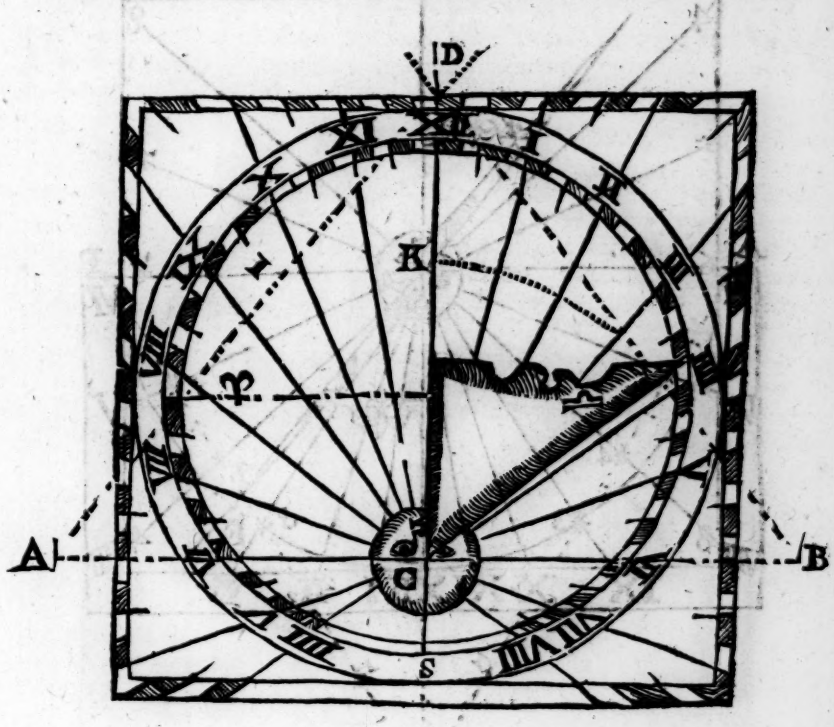
Take off the Scale of Hours the halfs and quarters, and prick from D as you did the Hours, and draw the quarters in the Dial as you were directed for the Hours.

For the Stiles height, with a Chord of 60 *deg.* describe the Arch K E, and lay the Chord of the Latitude 51 *deg.* ½ from K to E, then from the Center C draw the Line C E, which is the Stile for this Dial.

To find the hour distances by the Logarithms.

Example for 1 *hour from* 12.

As the Sine of 90 *d. is to the Sine of the Latitude* 51 *d.* 30 *m.*	989354
So is the Tangent of 15 *d. for* 1 *hour*	942805
To the Tangent of the Hour distance from the Merid. 11 *d.* 50 *m.*	932159



In

In this Table you have the distance of 5 hours on either side the Substile or hour of 12, which take from the Line of Chords, and prick from the hour of 12 on the Arch K E on each side; And by the same Rule that you found the hours you may find the Quarters, and prick them off in like manner.

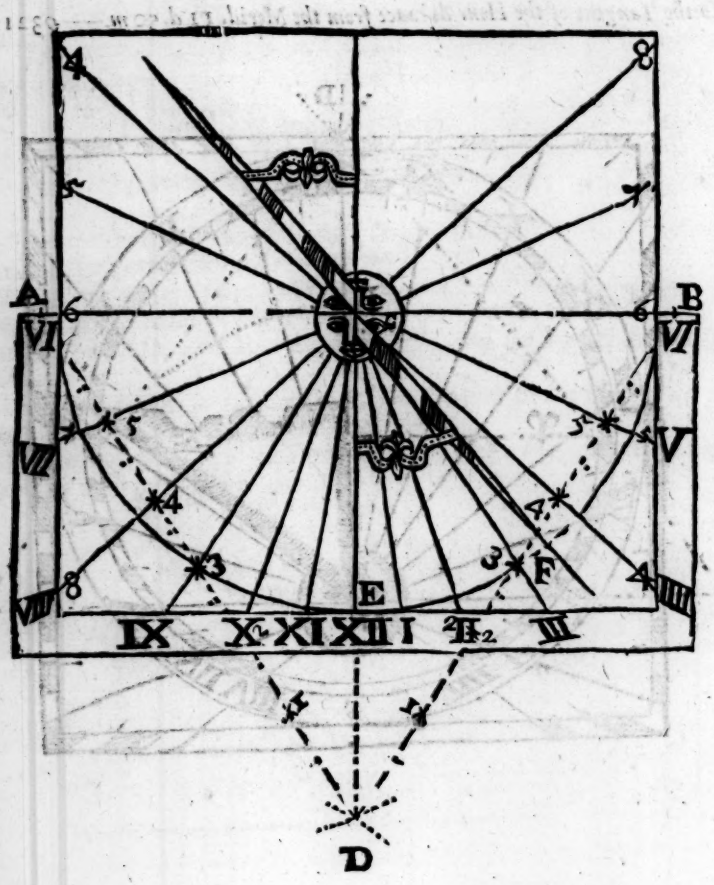
Hours.	*Gr. min.*	*Gr. min. Tangents.*
12	00 00	00 00
1	15 00	11 50
2	30 00	24 20
3	45 00	28 3
4	60 00	53 35
5	75 00	71 96

CHAP. VIII.

A South or North Horizontal Dial, commonly called, an upright North or South Dial, and how to make it.

THis belongs to an upright Wall looking full North or South, and the Plane of it lies in the prime Vertical.

First, draw the Horizontal-line A B, which serveth for 6 in the morning at A, and 6 in the afternoon at B, then from the Center C lay down from the Line



of

of Latitudes the Complement of the Latitude 38. 30 both ways, to A and B: Then with the whole Line of 6 hours from A describe an Arch towards D, and with the same distance from B cross the same Arch, and draw the two Lines A D and B D, whereon from D you must place the Hours, as you see by the Figures 1, 2, 3, 4, 5. So drawing Lines through those Points from the Center C, you shall have the hours from six a clock in the morning to six a clock in the afternoon. Then with the Chord of 60 on the Center C, describe the Semicircle A E B, from which Line of Chords take the Complement of the Latitude 38. 30. and lay it down from the Meridian at E unto F, so drawing C F you shall have the height of the Stile above the Plane; which, if it be for a large Dial against a Wall, is best to be a Rod of Iron; for small Dials a Brass Plate is best.

	90	
Lat.	51	30
Compl.	38	30

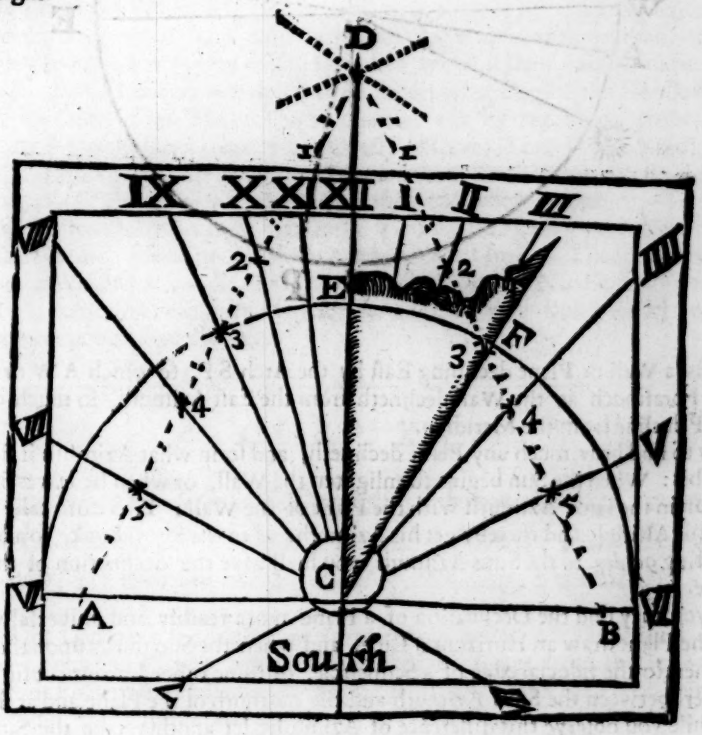
The South Dial shews the Hours from 6 in the morning to 6 at night: The other hours before and after 6, as far as four and eight, belong to the North face of this Dial.

The North Plane shews the hours from 4 in the morning to 8, and from 4 in the afternoon till 8 at night, the Sun shining no longer thereon in this Latitude; and as in the South Plane the Stile points downwards towards the South Pole, so in the North Plane it points upwards towards the North Pole.

CHAP. IX.

How to delineate a South Plane Reclining 67 deg. in the Latitude of 51 deg. 30 min. Northerly.

IN South Recliners or North Incliners, the difference between the Complement of the Latitude of the place; and the Reclination or Inclination is the Stiles height.



In

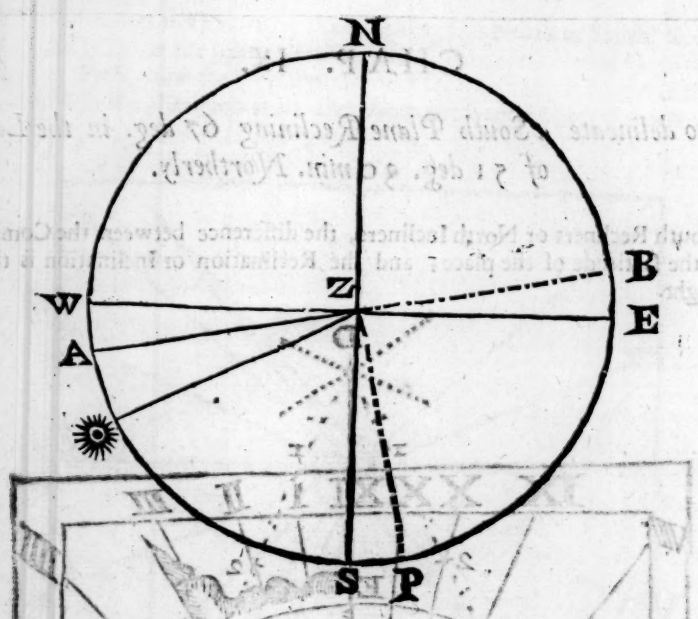
In North Recliners or South Incliners the ſum of the Complement of the Latitude and the Reclination or Inclination is Stiles height, which if it exceeds 90 *deg.* ſubtract it from 180 *deg.* the remainder is the Stiles height.

So in this Plane the Stiles height is 28 *deg.* ½; and you may delineate the Plane as if you were to draw an Horizontal Dial for the Latitude of 28 *deg.* ½.

CHAP. X.

How to find the Declination of a Plane.

ALL perpendicular Planes, as Walls, lie in ſome Azimuth, whoſe Planes cut both Zenith and Nadir, and the Center of the Earth, as in the Figure Z is Zenith E S W N, the Horizon, E W is the Horizontal Line drawn upon a Wall or Plane, looking full South or North, its Poles are at S and N in the Meridian; wherefore it declineth not.



A B is a Wall or Plane declining Eaſt by the Arch S P, to which A W or B E are equal: Foraſmuch as the Wall declineth from the Eaſt Azimuth, ſo much doth its Pole at P decline from the Meridian.

Now to find how much any Plane declineth, and ſo in what Azimuth it lies, one way is this: When the Sun begins to enlighten the Wall, or when he leaves it, then is the Sun in the ſame Azimuth with the Plane of the Wall: Therefore take at that inſtant his Altitude, and thereby get his Azimuth, as in the Sixth Book, ſo adding or ſubtracting 90 *deg.* to the Suns Azimuth, you ſhall have the declination of the Wall or Plane.

But you may find the Declination of a Plane more readily and univerſally thus: Upon the Plane draw an Horizontal Line, and when the Sun ſhines upon the Plane, apply thereto the fiducial edge of a Semicircle, or ſome other Inſtrument fit to take the differ. between the Suns Azimuth and the Azimuth of the Plane, and at the ſame time while you obſerve this difference of Azimuths let another take the Suns Altitude: This done, by the Latitude of the place, the Suns Altitude and Declination,

you

you may find the Suns Azimuth, and this being compared with the Difference of the Planes Azimuth therefrom, either wanting or paſt, the Pole of the Plane, will give the Planes Declination; an Example or two will render it more intelligible.

Example 1.

In the Afternoon I obſerve the Sun (to the Weſtward, or) paſt the Pole of the Plane 72 *deg.* and at the ſame time taking the Suns Altitude, thereby I find the Suns Azimuth to be South 62 *deg.* Weſt, and therefore the Planes Declination is South 10 *deg.* Eaſt; for the Meridian of the place lies between the Sun and the Pole of the Plane, therefore the difference between 72 *deg.* and 62 *deg. viz.* 10 *deg.* is the Declination of the Plane; and this is evident by the preceding Scheme, wherein P ⊙ repreſents the Suns Diſtance from the Pole of the Plane, and S ⊙ the Suns diſtance (or Azimuth) from the South towards the Weſt, and S P the difference between thoſe Arches, is the Declination, of the diſtance of P the Pole of the Plane from the South towards the Eaſt.

Example 2.

In the Forenoon the Suns diſtance from the Pole of the Plane wanting (or to the Eaſtward thereof) is 30 *deg.* and the Suns Azimuth (found by its Altitude) is S 40 E, and the Declination of the Plane is South 10 *deg.* Eaſterly.

And thus if you draw a Scheme you may ſoon reaſon out the Declination, better then do it blindfold, by the Rules commonly given: And this ſerves not only of upright Planes, but of Reclimers, or Inclimers alſo.

How to find the Declination by the Needle when the Sun doth not ſhine.

APply the North ſide of a ſquare Box wherein there is fitted a Magnetical Needle unto the Wall, and hold it Horizontally as near as you can, that the Needle may have liberty to play to and fro; and when it ſtands ſtill obſerve upon the Limb of the Chard over which it moves, upon what Degree the Needle ſtands; for that is the Declination of the Plane, pointed out by the South point of the Needle: And if you would know the Coaſt, obſerve, That if the Needle ſtand upon the Eaſt ſide of the Meridian Line, then is the Declination Weſt; but if it ſtand on the Weſt ſide of the Meridian Line, the Declination is Eaſt.

In uſing the Needle, take theſe Cautions, 1. That in all places there is a variation of the Needle, which muſt be known and allowed for. 2. That Iron bars and Caſements in Windows, as alſo Brick Walls will diſtort the Needle, and therefore you muſt not come too near them, but ſet the edge of your Box parallel to thoſe Planes at ſome convenient diſtance.

CHAP. XI.

How to find the requiſites in a Declining Horizontal Dial, commonly called a South erect Decliner, declining from the South Eaſtwards 32 deg. 30 min. *in the Latitude of* 51 deg. 30 min.

IN upright Decliners we muſt find three things before the Hour-lines can be drawn upon the Plane; *viz.* 1. The Subſtiles diſtance from the hour of 12, which is Planes Perpendicular. 2. The Stiles height above the Plane, being the Angle betwixt the Subſtile and the Stile. 3. The Inclination of Meridians, being the Angle between the two Meridians of the place, and of the Plane.

To find theſe Requiſites Geometrically, proceed thus:

Firſt, Draw the Horizontal-line A B, and upon the Center at C, with a Chord of 60 Degrees, deſcribe the Semicircle A D B, and lay the Chord of 90 from A to D, and from B to D, and draw C D for the line of 12 a clock; Then take the Complement of the Latitude 38 *deg.* 30 *min.* and lay from D to F, and ſo draw E F parallel to A B; next take the Declination of the Dial 32 *deg.* 30 *min.* and lay it from D to G, drawing the Radius C G, thereon you muſt lay the diſtance E F, from C to H. Now the neareſt diſtance from H to the Meridian C D, as H I, lay from F to L, then draw a Line from C through L, it will cut the Limb in the Point M; ſo meaſuring D M on the Line of Chords, you ſhall have the Subſtiles diſtance 23 *deg.*

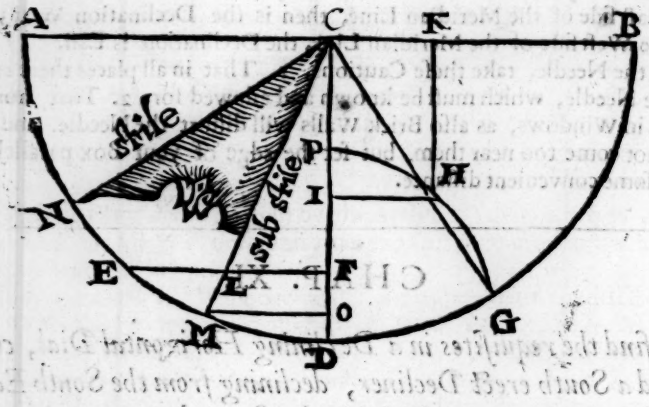
By Calculation by the Logarithms.

As the Radius 90 *deg.*	1000000
Is to the Sine of the Declination S E 32 *deg.* 30 *m.*	973021
So is the Co-tangent of the Latitude 51 *d.* 30 *m.*	990060
To the Tan. of the Subſtiles diſtance from the Meridian 23 *d.* 8 *m.*	963081

For the height of the Stile, take the neareſt diſtance from H to the Line A B, as H K, and lay the ſame from L to cut the Arch D A (extended if need be) in N. So meaſure M N, on the Line of Chords gives the height of the Stile 31 *deg.* ¼.

By Calculation, *viz.*

As the Radius 90 *deg.*	1000000
Is to the Co-ſine of the Latitude 51 *deg.* 30 *min.*	979414
So is the Co-ſine of the Declination 32 *deg.* 30 *min.*	992602
To the height of the Stile 31 *deg.* 40 *min.*	972016



To find the Inclination of Meridians.

TAke the neareſt diſtance from M to F E, and lay it on the Meridian from F to O: Then take the Diſtance from O unto G, and lay it from O unto P on the Meridian (extended if need be) ſo the diſtance from P to M, meaſured on the Line of Chords, will be found to be 39 *deg.* which is in time (allowing 15 *deg.* for an hour, and

and four Minutes to a Degree) 2 *hours* 36 *min.* So that the Subſtile in this Dial falls between 9 and 10 of the Clock in the morning.

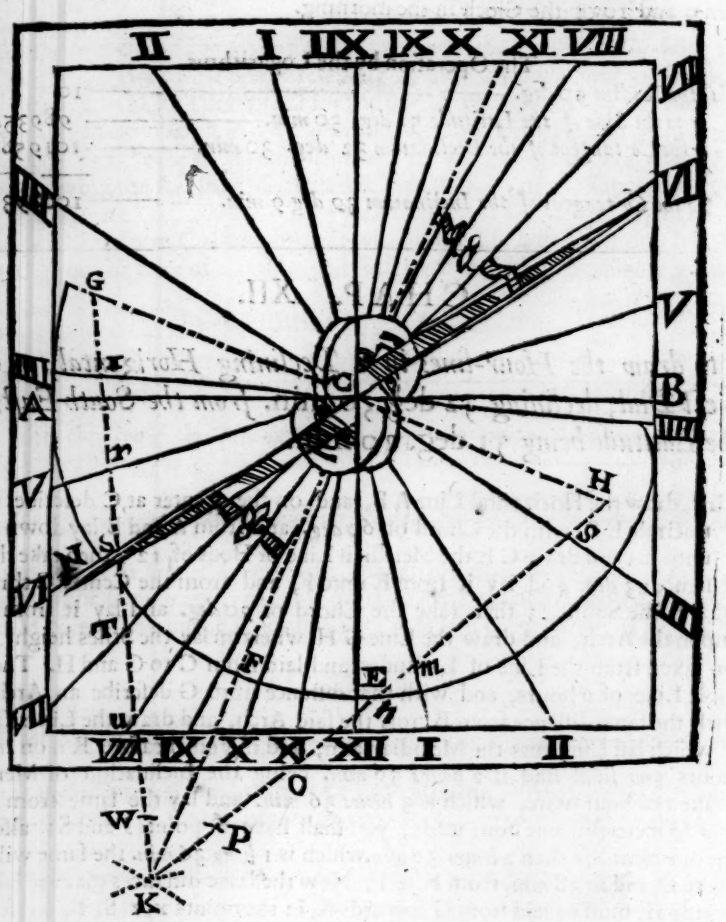
The Operation by the Logarithms.

As the Radius 90 *deg.*	10
Is to the Sine of the Latitude 51 *deg.* 30 *min.*	989354
So is the Co-tangent of the Declination 32 *deg.* 30 *min.*	1019581
To the Co-tangent of the Inclination 39 *deg.* 9 *min.*	1008935

CHAP. XII.

How to draw the Hour-lines in a Declining Horizontal, or South erect Dial, declining 32 deg. 30 min. *from the South Eaſtward, the Latitude being* 51 deg. 30 min.

FIrſt, draw the Horizontal Line A B, and on the Center at C deſcribe the Semicircle E B, with the Chord of 60 *deg.* and from A and B lay down 90 *deg.* unto E; and draw C E the Meridian Line or Hour of 12; then take the Subſtiles diſtance 23 *deg.* and lay it from E unto F, and from the Center C through F draw C F K the Subſtile; then take the Chord of 90 *deg.* and lay it from F both ways upon the Arch, and draw the Line G H, whereon lay the Stiles height 31 *deg.* 40 *min.* taken from the Line of Latitudes, and laid from C to G and H. Then take the whole Line of 6 hours, and with that diſtance from G deſcribe an Arch at K, and with the ſame diſtance from B croſs the ſaid Arch, and draw the Lines G K and H K,: which laſt Line cuts the Meridian at n, and if you meaſure K n on the Line of 6 hours you ſhall find it 2 *hours* 36 *min.* being the Inclination of Meridians. Then take one hour more, which is 3 *hours* 36 *min.* and lay the ſame from K unto M; and ſo increaſing one hour more, you ſhall have the points *l* and S; alſo diminiſhing one hour leſs than 2 *hours* 36 *min.* which is 1 *hour* 36 *min.* the ſame will reach from K to O, and ſo 38 *min.* from K to P. Now the ſame diſtances that are laid from K towards H, muſt be laid from G towards K, in the points x, z, S, T, u; ſo drawing the Lines from the Center C through thoſe Points, you ſhall have the Hour-lines, as you ſee in the Dial following.



How to Calculate the hour-distances by the Logarithms.

Example.

TO find the distance of the hour of 10 from the Substile. The Angle betwixt the hour of 10 and the Substile is *9 deg. 9 min.*

As the Radius —— 100000

Is to the Sine of the Stiles Height 31 deg. 40 min. —— 972013
So is the Tangent of the Angle from the Substiles 9 deg. 9 min. —— 920701

To the Tangent of the Hour-distance from the Substile 4 d. 50 m. — 892714

And so you may find the distance of any other hour Line, from the Substile, as in the following Table, under the Title of *hour distances.*

In

In this Table the Angles of the hour-lines with the Subſtile, under the Title of *hour Angles*, are thus found. From the Inclination of Meridians 39 *deg.* 9 *min.* ſubtract 15 *deg.* leaves 24 *deg.* 9 *min.* for the hour of 11; from 24 *deg.* 9 *min.* ſubtract 15 *deg.* leaves 9 *deg.* 9 *min.* for the hour of 10; then ſubtract 9 *deg.* 9 *min.* from 15 *deg.* leaves 5 *deg.* 51 *min.* for the hour of 9; to 5 *deg.* 51 *min.* add 15 *deg.* makes 20 *deg.* 51 *min.* for the hour of 8; and ſo continue to add 15 *deg.* till you make 80 *deg.* 51 *min.* for the hour of 4 in the Morning: Likewiſe add 15 *deg.* to 39 *deg.* 9 *min.* makes 54 *deg.* 9 *min.* for the hour of 1; and 15 *deg.* more makes 69 *deg.* 9 *min.* for the hour 2, and 15 *deg.* more makes 84 *deg.* 9 *min.* for the hour of 3 afternoon.

Hours.	*Hour Angles.* D.	M.	*Hour Diſtan.* D.	M.
4	80	51	72	57
5	65	51	49	30
6	50	51	32	49
7	35	51	20	46
8	20	51	11	18
9	5	51	3	5
	Meridian.		*Subſtile.*	
10	9	9	04	50
11	24	9	13	15
12	39	9	23	8
1	54	9	36	0
2	69	9	54	2
3	84	9	78	57

Thus was this Table made; and ſo you may make one for any Latitude, and for any Declining Dial; and by it prove your former Work: For if you prick from the Subſtile C F the Chord of 4 *deg.* 50 *min.* and draw a Line from the Center, it will be the Hour-line of 10; and prick the Chord of 3 *deg.* 5 *min.* from the Subſtile, and draw a Line through that Point to the Center, and it will be the Hour line of 9 a clock; and ſo of the reſt, as you find them in the laſt Column.

Note, That becauſe the Plane declines Eaſt, therefore the Subſtile ſhall decline Weſt: For the Dial being ſuch a Projection of the Sphere, wherein all the uſual Lines croſs in the Nodus of the Gnomon, and thence diſperſe themſelves again towards the Plane; therefore that which is Eaſt in the Sphere, will be expreſſed Weſt on the Plane, and contrarily as was ſaid *Chap.* 2. *Theorem* 11. Again conſider, that howſoever the Plane be declined Eaſt or Weſt, the Gnomon is fixed, becauſe it is a part of the Axis of the World, or a Line Parallel to it. Now therefore move a *South* Dial, and make it decline Eaſt, holding the Gnomon unmovable, the Weſt ſide of the Dial will approach nearer to the Gnomon.

And if you would draw the North Dial on the oppoſite ſide of this Plane, prolong thoſe Hour-lines, and the Subſtile upwards beyond the Center, and you have the North Dial beyond C, or above the Horizontal Line A B, and the *South* Dial below it.

CHAP. XIII.

How to delineate an Eaſt or Weſt Reclining or Inclining Dial.

AS the Horizontal-line of a *South* Recliner lieth in the Eaſt Azimuth; ſo the Horizontal-line of an Eaſt Recliner lieth always in the Meridian of the Place: And as all Declining Planes lie in ſome Azimuth, which croſs one another in the Zenith and Nadir, ſo theſe Reclining Planes lie in ſome Circle of Poſition, which croſs one another in the North and *South* Points of the Horizon; which being conſidered, theſe Eaſt and Weſt Incliners and Recliners, ſhall be made as eaſily as the upright Decliners.

For theſe Dials are upright Decliners to thoſe that live 90 *deg.* from us Northward or *South*ward, who have one of their Poles elevated as much as the Complement of our Latitude.

To

To find the Reclination or inclination of a Plane, proceed thus: On the Plane draw an Horizontal Line, and croſs it at right Angles, that Line is the Planes Perpendicular, to which apply the ſtreight edge of a long Ruler that may over-hang the Plane, and to this edge of the Ruler apply the fiducial Ray of a ſmall Quadrant, the plumb line playing upon the limb of the Quadrant, will give you the Reclination or Inclination of the Plane.

To find the Subſtiles diſtance from the hour of 12. by Logarithms.

As the Radius ——— 1000000
Is to the Sine Compl. of Reclination 45 *deg.* ——— 984948
So is the Tangent of the Latitude 51 *deg.* 30 *min.* ——— 1009939

To the Tangent of the Subſtiles diſtance 41 *deg.* 38 *min.* ——— 994887

Or upon *Gunter's* Ruler, Extend the Compaſſes from the Sine of 90 *deg.* to the Sine of 45 *deg.* the ſame extent will reach from the Tangent of the Latitude 51 *deg.* 30 *min.* to 41 *deg.* 38 *min.*

Secondly, The height of the Stile above the Plane is found thus by the Logarithms.

As the Sine of 90 ——— 1000000
To the Sine of 51 *deg.* 40 *min.* ——— 989354
So is the Sine of Reclination 45 *deg.* ——— 984948

To the Sine of the Stiles height 33 *d.* 36 *m. or Pole above the Plane* 974302

Extend the Compaſſes from the Sine of 90 *deg.* to the Sine of 51 *deg.* 30 *min.* the ſame Extent will reach from the Sine of Reclination 45 *deg.* to 33 *deg.* 36 *min.* the height of the Stile.

3. To find the Inclination of Meridians by the Logarithms.

As the Sine of the Latitude 51 *deg.* 30 *min.* ——— 989354
To the Sine of 90 *deg.* ——— 1000000
So is the Sine of the Subſtiles Diſtance 41 *deg.* 38 *min.* ——— 982240

To the Sine of Inclination of the Meridians 58 *deg.* 05 *min.* — 992886

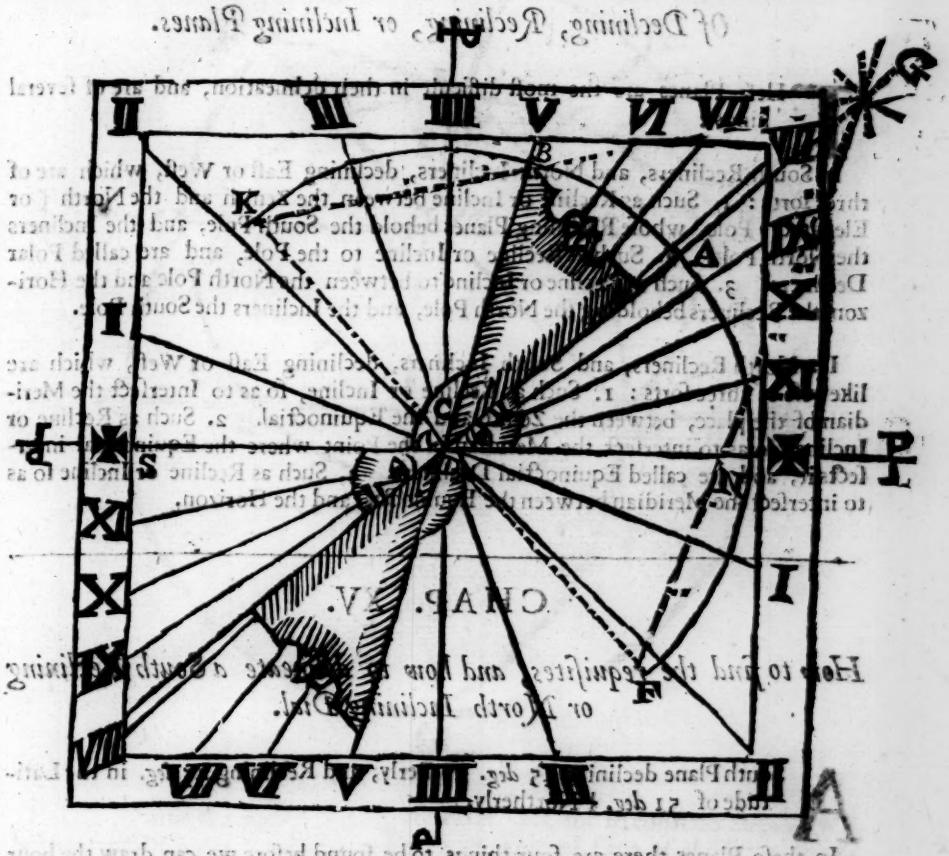
Extend the Compaſſes from the Sine 51 *deg.* 30 *min.* the Sine of 90; the ſame Extent will reach from 41 *deg.* 38 *min.* the Subſtiles diſtance, to 58 *deg.* 05 *min.* which reſolved into time, doth make about 3 *hours*, 52. *min.* and ſo the Subſtile will fall near the Hour of 8 in the morning.

To draw the Hour-lines on the Eaſt Recliner.

DRaw the Planes Horizontal Line S N, which is hour of 12 in Eaſt and Weſt Incliners or Recliners; then with the Chord of 60 *deg.* deſcribe the Arch F A K, and ſet off the *S*ubſtiles Diſtance 41 *deg.* 38 *min.* from N to A, and draw the *S*ubſtile C A, and croſs it at right Angles with the Line F C K; then ſet off the *S*tiles height 33 *deg.* 36 *min.* from A to B, and draw the *S*tile C B: Then take off the *S*tiles height 33 *deg.* 36 *min.* from the Line of Latitudes, and lay it from C to F and K, then with the diſtance of 6 hours from the *S*cale, ſetting your Compaſſes at F, and then at K, deſcribe the two occult Arches at G, and to their interſection draw the Lines F G and K G. From the *S*cale of ſix hours take the Inclination of Meridians 3 *hours*, 52 *min.* and laying from G it will reach to N (in the Line G F)

for

for the hour of 12, and from K it will reach in the Line G K to the Point where the hour of 6 intersects that Line: so take the distance of 4 *hours*, 52 *min.* and set off from G on the Line F G, for the hour of 1 afternoon, and the same distance from K on the Line G K, for the hour of 7 in the morning; in the same manner



place the distance of 5 *hours*. 52 *min.* from G for the hour of 2, and from K for the hour of 8; likewise the distance of 2 *hours*, 52 *min.* from G for the hour of 11, and from K for the hour of 5; and so the distance of 1 *hour*, 52 *min.* from G and K for the hours of 10 and 4, and the distance of 52 *min.* from G for the hour of 9; through these Points draw the hour-Lines, and finish your Plane.

The hours proper for this Plane, are from 4 in the Morning till 2 in the Afternoon.

If you continue the Substile, the Stile and hours of 4, 5, 6, 7, and 8 in the Morning below the Center C, they shew how they will fall upon a West Plane Inclining 45 *deg.* with this caution, that the hours of 1, 2, *&c.* in the Afternoon which are here on the North side of the East Plane, must be placed there on the North side of the West Plane, and so for the hours of 5, 6, 7, and 8, on the South side of the Plane.

CHAP.

CHAP. XIV.

Of Declining, Reclining, or Inclining Planes.

THeſe Planes are the moſt difficult in their delineation, and are of ſeveral kinds:

I. South Recliners, and North Incliners, declining Eaſt or Weſt, which are of three ſorts: 1. Such as Recline or Incline between the Zenith and the North (or Elevated) Pole, whoſe Reclining Planes behold the South Pole, and the Incliners the North Pole. 2. Such as Recline or Incline to the Pole, and are called Polar Decliners. 3. Such as Recline or Incline to between the North Pole and the Horizon, the Recliners beholding the North Pole, and the Incliners the South Pole.

II. North Recliners, and South Incliners, declining Eaſt or Weſt, which are likewiſe of three ſorts: 1. Such as Recline or Incline, ſo as to Interſect the Meridian of the place, between the Zenith and the Equinoctial. 2. Such as Recline or Incline ſo as to interſect the Meridian in the Point where the Equinoctial interſects it, and are called Equinoctial Decliners. 3. Such as Recline or Incline ſo as to interſect the Meridian between the Equinoctial and the Horizon.

CHAP. XV.

How to find the requiſites, and how to delineate a South Reclining or North Inclining Dial.

A South Plane declining 45 *deg.* Weſterly, and Reclining 45 *deg.* in the Latitude of 51 *deg.* ½ Northerly.

In theſe Planes there are four things to be found before we can draw the hour Lines.

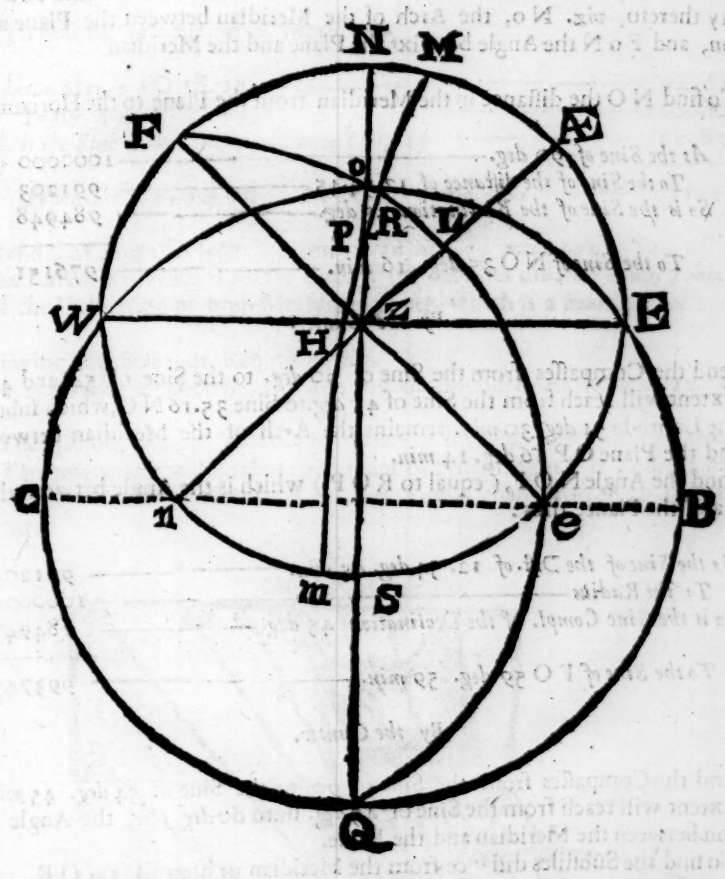
1. The diſtance of the Meridian (or hour of 12) from the Horizontal Line of the Plane, or from the Perpendicular thereof.

2. The Subſtiles diſtance from the hour of 12, or from the Planes Perpendicular.

3. The Stiles height.

4. The Inclination of Meridians, which are illuſtrated in the following Scheme.

In



In this Scheme the Arch F L E is the Plane, Z L the Reclination thereof, F E the Horizontal Line of the Plane, and Æn the Vertical Line of the Plane, or the Planes Perpendicular, S n is the Declination of the Plane, m H P M the Meridian of the Plane or Subſtile, paſſing by the North Pole at P, cutting the Plane at Right Angles at R, and paſſing through the Pole thereof at H, F o the diſtance of the hour of 12 from the Planes Horizontal Line; O R the Subſtiles diſtance from the hour of 12, R L the Subſtiles diſtance from the Planes Perpendicular, P R the Stiles height or the Elavation of the North Pole above the Plane; O P R the Inclination of Meridians.

To find the diſtance of 12 from the Horizontal Line of the Plane, ſay,

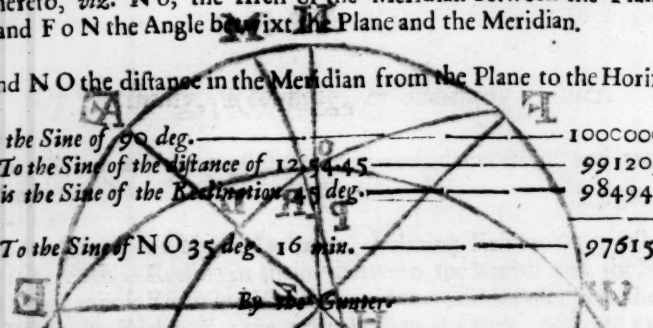
As the Sine of 90	1000000
To the Sine Comp. of the Reclination 45 *deg.*	984948
So is the Tangent of Declination 45 *deg.*	1000000
To the Co-tangent of 54 *deg.* 45 *min.*	984948

Which is the Arch of the Plane between the Horizon and Meridian, or the diſtance of the hour of 12.

By the *Gunter.*

Extend the Compaſſes from 90 to 45 upon the Sines, the ſame Extent will reach from the Co-tangent 45 to Tang. 35. 15. whoſe Comp. 54 *deg.* 45 *min.* is the diſtance of 12.

To find the Subſtiles diſtance from the hour of 12 O R, we muſt find two things adjutory thereto, *viz.* N o, the Arch of the Meridian between the Plane and the Horizon, and F o N the Angle betwixt the Plane and the Meridian.



To find N O the diſtance in the Meridian from the Plane to the Horizon.

As the Sine of 90 *deg.* —— 1000000
To the Sine of the diſtance of 12. 54. 45 —— 991203
So is the Sine of the Declination 45 *deg.* —— 984948

To the Sine of N O 35 *deg.* 16 *min.* —— 976151

By the Gunter.

Extend the Compaſſes from the Sine of 90 *deg.* to the Sine of 54 and 45, the ſame Extent will reach from the Sine of 45 *deg.* to Sine 35.16 N O, which ſubtracted from the Latitude 51 *deg.* 30 *min.* remains the Arch of the Meridian between the Pole and the Plane Q P 16 *deg.* 14 *min.*

To find the Angle N O F, (equal to R O P) which is the Angle between the Meridian and the Plane, thus:

As the Sine of the Diſt. of 12. 54 *deg.* 45 *min.* —— 991203
To the Radius —— 1000000
So is the Sine Compl. of the Declination 45 *deg.* —— 984948

To the Sine of F O 59 *deg.* 59 *min.* —— 993745

By the Gunter.

Extend the Compaſſes from the Sine of 90, to the Sine of 54 *deg.* 45 *min.* the ſame Extent will reach from the Sine of 45 *deg.* unto 60 *deg. fere*, the Angle of Inclination between the Meridian and the Plane.

2. To find the Subſtiles diſtance from the Meridian or hour of 12, O R.

As the Sine of 90 *deg.* —— 1000000
To the Co-ſine of P O R, 59 *deg.* 59 *min.* —— 969918
So is the Tangent P O 16. 14 —— 946412

To the Tang. of the Subſtiles diſt. from 12 O R 8 *deg.* 17 *min.* — 916330

By the Gunter.

Extend the Compaſſes from the Sine of 90 *deg.* to the Co-ſine of 59 *deg.* 59 *min.* the ſame diſtance will reach from the Tangent of 16. 14. to the Tangent of the Subſtile from the Meridian 8 *deg.* 17 *min.*

3. To find the Elevation of the Pole above the Plane or Stiles height.

As the Sine of 90 *deg.* —— 100000
To the Sine of P O 16. 14 —— 944646
So is the Sine of P O R 59 *deg.* 59 *min.* —— 993746

To the Sine of P R *the Stiles height above the Plane* 14. 1 —— 9383942

Or, Extend the Compaſſes from the Sine of 90 *deg.* to the Sine of 16 *deg.* 14 *min.* the ſame diſtance will reach from the Sine of 59 *deg.* 59 *min.* to the Sine 14 *deg.* 1 *m.* the Stiles height.

4. To

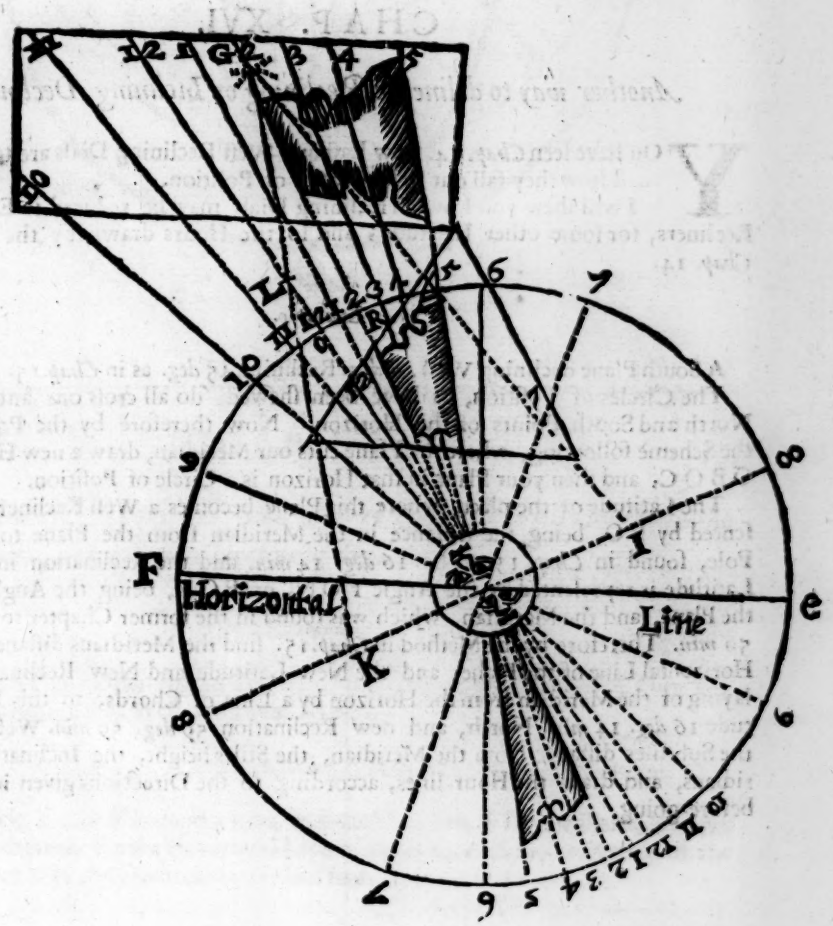
4. To find the Inclination of Meridians.

As the Sine of PO 16. 14	944646
To the Sine of 90 *deg.*	1000000
So is the Sine of the Subſtile diſtance 8 *deg.* 17	915857
To the Inclination of Meridians 31 *deg.* 1 *min.*	971211

Extend the Compaſſes from the Sine of 16 *deg.* 14 *min.* to the Sine of 90 *deg.* the ſame Extent will reach from the Sine of the Subſtiles diſtance 8 *deg.* 7 *min.* to the Sine of the Inclination of both Meridians 31 *deg.* which is 2 *hours* 4 *min.*

Having got theſe four Requiſites, *viz.*

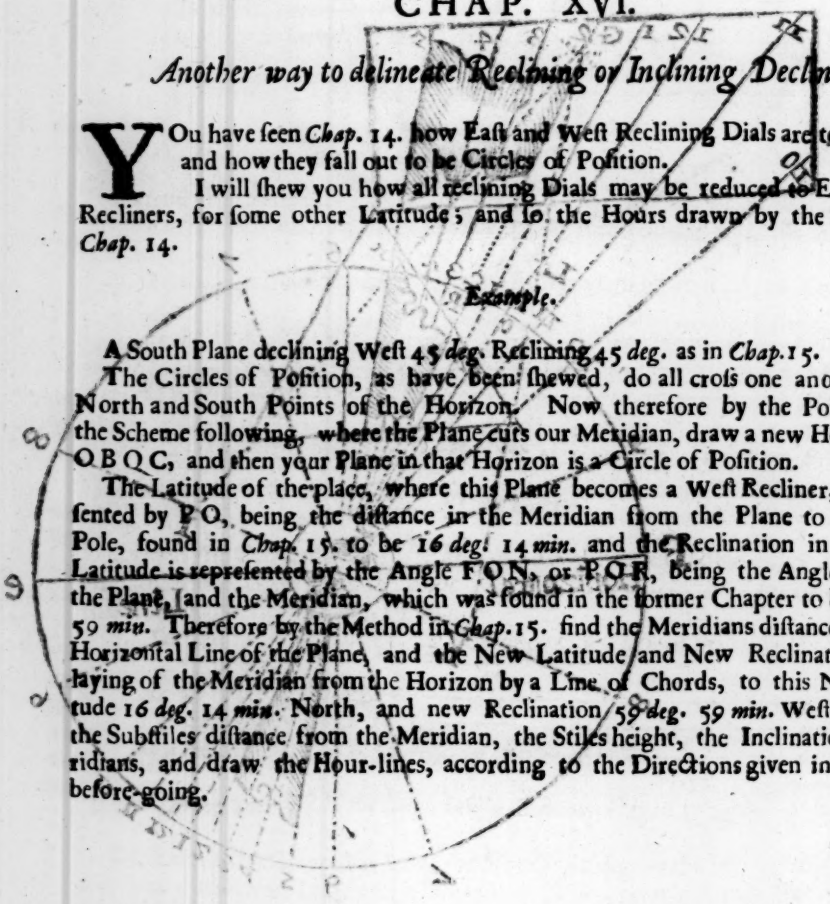
1. The diſtance between the Horizon and the Meridian or hour of 12, 54 *deg.* 45 *min.*
2. The Subſtile diſtance from the Meridian of the Place O R 8 *deg.* 17 *min.*
3. The height of the Pole above the Plane or Stiles height P R 14 *deg.* 1 *min.*
4. The Inclination of Meridians 31 *deg.* 1 *min.* then proceed to delineate the Dial thus.



First, draw the Horizontal Line F e, and with the Chord of 60 *deg.* and ſweep the Circle F O R e; then take off the Chord of 54 *deg.* 45 *min.* the diſtance between the Horizon and the Meridian, and lay it from F to O: Then take off the Chords 8 *deg.* 17 *min.* the Subſtiles diſtance, and lay it from O to R; then from the Center draw the hour of 12 and the Subſtile; and croſs the Subſtile at right Angles with the Line I K; then take off the Stiles height 14 *deg.* 1 *min.* from the Line of Latitudes, and lay it both ways from C to K and I; then take off the whole Line of 6 hours, and from K toward G, and from I toward G, ſtrike the two occult Arches; and draw the Lines K G and I G; then extend the Compaſſes from G to the Meridian Line at L, and apply that diſtance to the Line of ſix hours, and you will find it to be 2 *hours* 4 *min.* which is the Inclination of Meridians as before: Then lay that diſtance from I toward G, for the hour of 6. and take (as before directed) 1 *hour*, 4 *min.* and lay it off in the ſame manner from G toward K, and from I toward G; and the like do with 3 *hours* 4 *min.* 4 *hours* 4 *min.* and 5 *hours* 4 *min.* Then draw the Hour lines in your Plane, whether it be a Triangle, Circle, or Square, for what ſhape ſoever; and lay off the height of your Stile 14 *deg.* 1 *min.* by the Line of Chords, and draw it from the Center, and ſo fit it to your Plane, as you may ſee in the Figure, and your Dial is done.

CHAP. XVI.

Another way to delineate Reclining or Inclining Decliners.



You have ſeen *Chap.* 14. how Eaſt and Weſt Reclining Dials are to be made; and how they fall out to be Circles of Poſition.

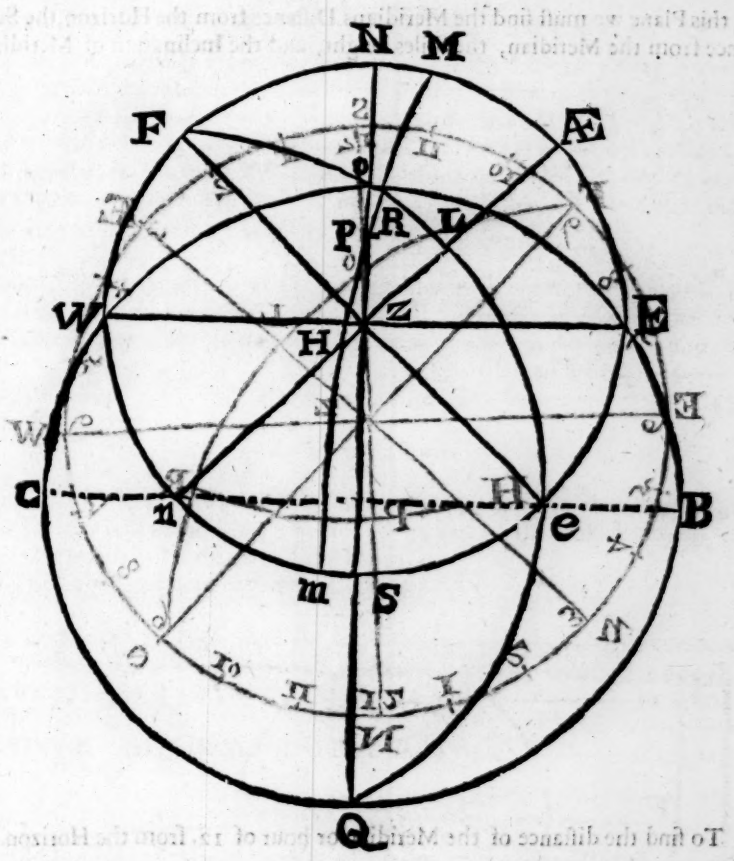
I will ſhew you how all reclining Dials may be reduced to Eaſt or Weſt Recliners, for ſome other Latitude; and ſo the Hours drawn by the Method of *Chap.* 14.

Example.

A South Plane declining Weſt 45 *deg.* Reclining 45 *deg.* as in *Chap.* 15.

The Circles of Poſition, as have been ſhewed, do all croſs one another in the North and South Points of the Horizon. Now therefore by the Point O, in the Scheme following, where the Plane cuts our Meridian, draw a new Horizon, as O B Q C, and then your Plane in that Horizon is a Circle of Poſition.

The Latitude of the place, where this Plane becomes a Weſt Recliner, is repreſented by P O, being the diſtance in the Meridian from the Plane to the North Pole, found in *Chap.* 15. to be 16 *deg.* 14 *min.* and the Reclination in this new Latitude is repreſented by the Angle F O N, or P O R, being the Angle between the Plane, and the Meridian, which was found in the former Chapter to be 59 *deg.* 59 *min.* Therefore by the Method in *Chap.* 15. find the Meridians diſtance from the Horizontal Line of the Plane, and the New Latitude and New Reclination, then laying of the Meridian from the Horizon by a Line of Chords, to this New Latitude 16 *deg.* 14 *min.* North, and new Reclination 59 *deg.* 59 *min.* Weſterly, find the Subſtiles diſtance from the Meridian, the Stiles height, the Inclination of Meridians, and draw the Hour-lines, according to the Directions given in *Chap.* 14. before-going.



CHAP. XVII.

How to find the Requisites, and how to delineate a North Declining Recliner, and a South Declining Incliner.

Example.

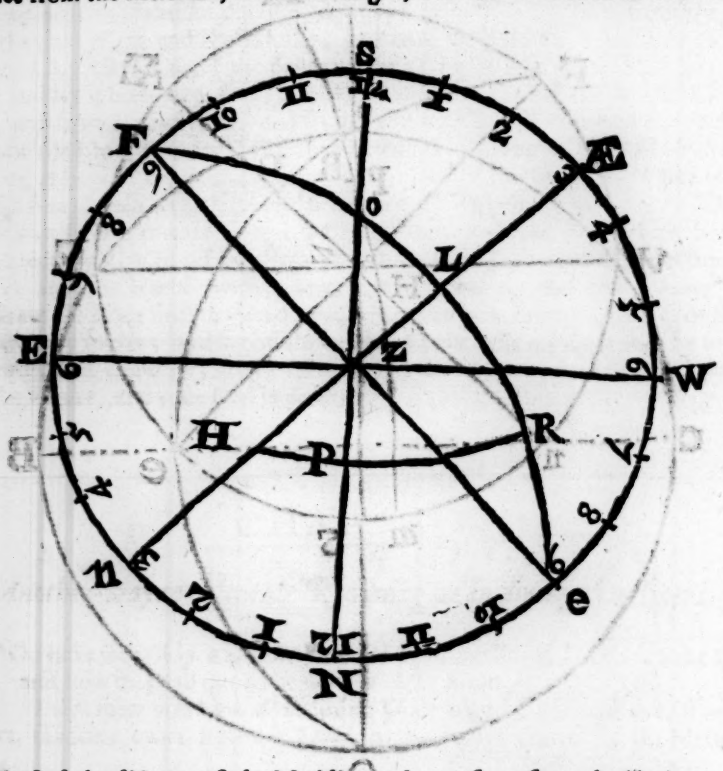
A North Plane Declining 45 *deg.* East, Reclining 45 *deg.* or a South Plane Declining 45 *deg.* West, Inclining 45 *deg.*

In the following Scheme.

The Circle E S W N is the Horizon, N S the Meridian, F L e the Plane, Z L the Reclination thereof, F e the Horizontal Line of the Plane, Æ N the Vertical of the Plane, S Æ or n N the Declination of the Plane.

In

In this Plane we muſt find the Meridians Diſtance from the Horizon, the Subſtiles diſtance from the Meridian, the Stiles height, and the Inclination of Meridians.



1. To find the diſtance of the Meridian or hour of 12. from the Horizon.

As the Sine of 90	1000000
To the Co-ſine of the Reclination 45 *deg.*	984948
So is the Tangent of Declination 45 *deg.*	1000000
To the Tangent Complement of F O 54 *deg.* 45 *min.*	984948

The Meridians diſtance from the Horizon.

By the Gunter.

Extend the Compaſſes from the Sine of 90 to the Sine of 45; the ſame Extent will reach from the Tangent of 45 *deg.* to the Tangent of 35 *deg.* 15 *min.* which ſubtracted from 40 *deg.* there remains 54 *deg.* 45 *min.*

To find the Subſtiles diſtance from the Meridian O R, firſt find S O the diſtance in the Meridian between the Horizon and the Plane; ſecondly, S O F equal to P O R the Angle between the Plane and the Meridian.

To find the Arch of the Meridian between the Horizon and the Plane S O, thus:

As the Sine of 90	1000000
Is to the Sine of the Arch of the Plane between the Horizon and Meridian F O 54. 45	991203
So is the Sine of Reclination 45	984948
To the Sine of the Arch of the Meridian between the Horizon and Plane S O 35 *deg.* 16 *min.*	976151

By

By the Gunter.

Extend the Compaſſes from the Sine of 90, to the Sine of 54 *deg.* 45 *min.* the ſame Extent will reach from the Sine of 45 *deg.* to the Sine of S O 35 *deg.* 16 *min.* which 35 *deg.* 16 *min.* taken out of 90 *deg.* there remains O Z 54 *deg.* 44 *min.* the Arch of the Meridian between the Zenith and the Plane; which being added to the Complement of the Latitude Z P 38 *deg.* 30 *min.* it makes P O 93 *deg.* 14 *min.* the Arch of the Meridian between the Pole and the Plane, then for the Angle between the Meridian and the Plane F O S, or P O R.

As the Sine of the Arch F O 54 *deg.* 45 *min.*	991203
Is to the Radius	1000000
So is the Co-ſine of the Declination F S 45 *deg.*	984948
To the Sine of the Augle F O S 59 *deg.* 59 *min.*	993745

By Gunter's Rule.

Extend the Compaſſes from the Sine of 54 *deg.* 45 *min.* to the Sine of 90 *deg.* the ſame Extent will reach from the Sine of 45 *deg.* to the Sine of 59 *deg.* 59 *min.* the Angle between the Meridian and the Plane.

2. To find the Subſtiler diſtance O R.

As the Sine of the Angle at R 90 *deg.*	1000000
To the Co-ſine of P O R 59 *deg.* 59 *min.*	969918
So is the Tangent of the Side P O 93 *deg.* 14 *min.*	112180
To the Tangent of the Subſtile O R 96 *deg.* 27 *min.*	10.94719

By the Gunter.

Extend the Compaſſes from the Sine of 90 *deg.* to the Sine of 30 *deg.* 1 *min.* the ſame Extent will reach from the Tangent of 86 *deg.* 46 *min.* to the Tangent of 83 *deg.* 33 *min.* whoſe Compl. to 180 *deg.* is 96 *deg.* 27 *min.*

3. For the Height of the Pole above the Plane, or Stiles height,

As the Radius	1000000
To the Sine of P O 93 *deg.* 14 *min.*	999831
So is the Sine of P O R 59 *deg.* 59 *min.*	993746
To the Sine of the Stiles height P R 59 *deg.* 49 *min.*	993577

4. To find the Inclination of Meridians O P R.

As the Sine of P O 93 *deg.* 14 *min.*	999831
To the Radius	1000000
So is the Sine of O R *the Subſtiles diſtance* 96 *deg.* 27 *min.*	999724
To the Sine of O P R *the Inclinat. Merid.* 95 *deg.* 35 *min.*	999793

Which 95 *deg.* 35 *min.* reduced to time make 6 *hours*, 22 *min.*

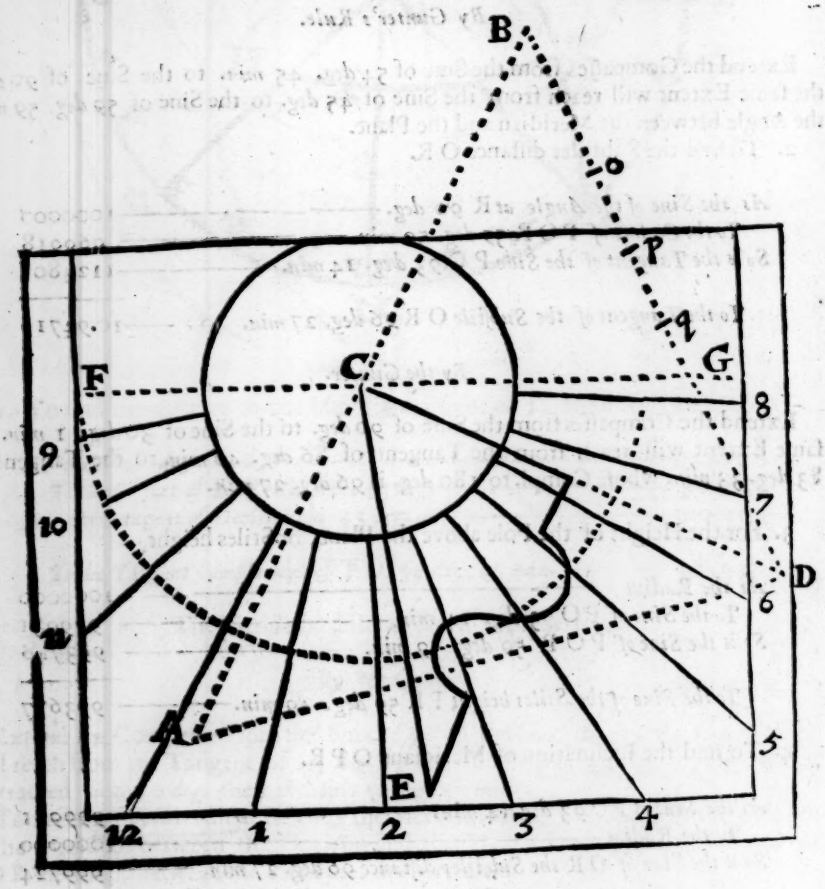
Having found the diſtance of the hour of 12 from the Horizon, 54 *deg.* 45 *min.* the Subſtiles diſtance from the hour of 12, 96 *deg.* 27 *min.* the Stiles height 59 *deg.* 49 *min.* and the Inclination of Meridians 95 *deg.* 35 *min.* or 6 *hours* 22 *min.* proceed to delineate the Southweſt Incliner, by the directions given in *Cha.* 15. or briefly thus:

Set

Set off the hour of 12 from the Horizon F G and the Subſtile C D from the hour of 12, and the Stile C E from the Subſtile by a Line of Chords, croſs the Subſtile at right Angles with the Line A C B, and laying off the Lines height (by the Line of Latitudes) from C to A and B, drawing D B and D A from thoſe two Points A and B, with the diſtance of ſix hours interſect the Subſtile in the Point D. The Inclination of Meridians being *6 hours*, 22 *min.* lay off 5 *hours* 22 *min.* and 4 *hours* 22 *min.* (by the Line of 6 hours) from D towards A for the hours of 1 and 2, and the ſame diſtances from B towards D, for the hours of 7 and 8; likewiſe 3 *hours* 22 *min.* 2 *hours* 22 *min.* 1 *hour* 22 *min.* from D for the hours of 3, 4, and 5, and from B for the Points o, p, and q; and laſtly 22 *min.* from D for the hour of 6. Note, the Points o, p, and q are to draw the hours of 9, 10, and 11 in the forenoon, on the other ſide the Center C.

The hours proper for this Plane are from 9 in the morning to 8 at night.

A South Plane Declining 45 *deg. Weſt Inclining* 45 *deg.*



Chap.

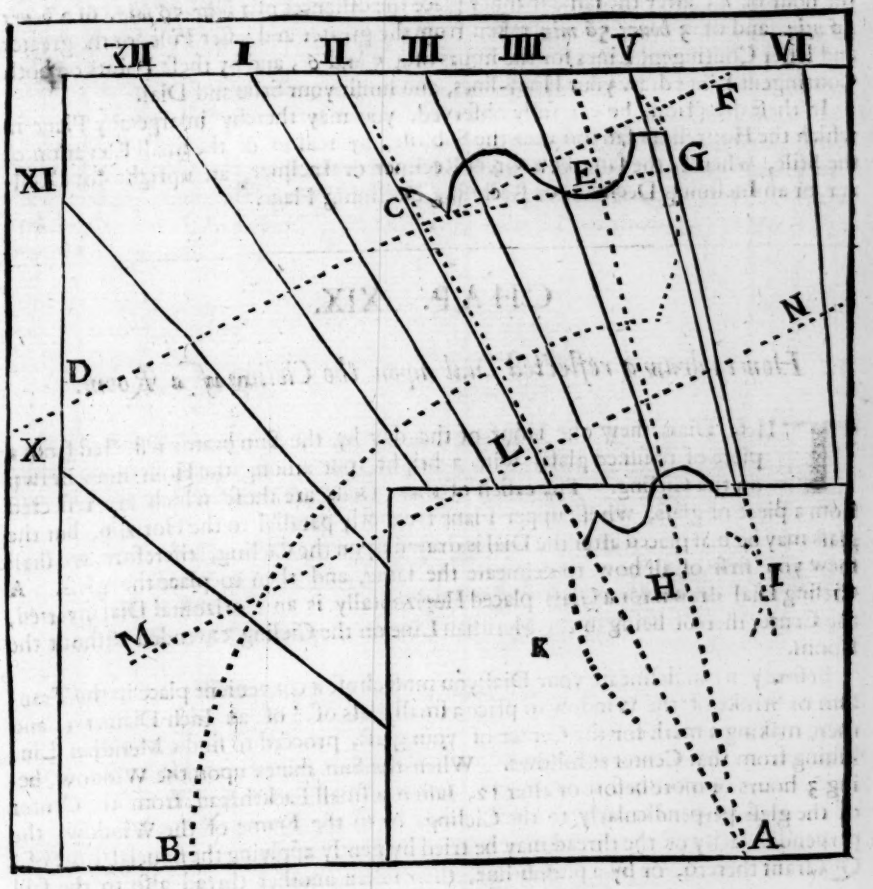
CHAP. XVIII.

How to delineate ſuch Planes wherein the Stiles height is ſmall, not exceeding 15 *degrees.*

IN theſe Planes the hour-lines fall ſo near the Subſtile, that they make the Dial unhandſom, and almoſt uſeleſs, and therefore we commonly inlarge them, by removing the Center of the hour-lines beyond the Dial Plane, drawing them by two Contingent Lines, by the help of Lines on the Mathematical Scale, called the greater and leſſer Pole; as follows.

For an Example, we will take the South Plane in *Chap.* 15, which declines 45 *deg.* Weſterly, and reclines 45 *deg.* In this Plane the Subſtiles diſtance from the Horizon is 63 *deg.* 02 *min.* for the Meridians diſtance from the Horizon was found to be 54 *deg.* 45 *min.* and the diſtance from the Meridian to the Subſtile 8 *deg.* 17 *min.* the ſame way, which added to 54 *deg.* 45 *min.* makes 63 *deg.* 02 *min.* the Stiles height is 14 *deg.* 01 *min.* and the Inclination of Meridians in time 2 *hours* 04 *min.* Now proceed to draw the Hour-lines on the Plane thus.

A Southweſt Plane Declining 45 *deg. and Reclining* 45 *deg.*



From the Herizontal Line A B ſet off the Subſtiles diſtance 63 *deg.* 02 *min.* and from the Subſtile the Stiles height 14 *deg.* 01 *min.* by the Line of Chords, and draw the Subſtile A C and the Stile A E; and from a convenient Point in the Subſtile as at C, draw the contingent Line D F at right Angles therewith; then from the Line called the greater Pole, take the diſtance of 3 hours, and ſetting your Compaſſes at C, deſcribe the occult Arch at G, and from the Point C draw the Line C E G Perpendicular to the Stile A E in the Point E, and with the Diſtance E G, upon the Point H, deſcribe the occult Arch at I, and by the Arches G and I draw the toucht line I G for the inlarged Stile: Then take the diſtance of 3 hours from the Line called the leſſer Pole, and ſetting your Compaſſes at I deſcribe the Arch at K, a Ruler laid from C to touch the Arch K, ſhall croſs the Subſtile in the Point L, from which Point draw the Contingent Line M N at right Angles with the Subſtile. Take the Inclination of Meridians 2 *hours* 04 *min.* of the greater Pole, and place it on the greater Contingent Line, from C towards D, and 2 *hours* 04 *min.* from the leſſer Pole, and place it on the leſſer Contingent Line, from L towards M, and by theſe two Points on the two Contingent Lines draw the hour of 12; likewiſe place 3 *hours* 04 *min.* of the greater Pole on the greater contingent Line, and the ſame diſtance of the leſſer Pole on the leſſer Contingent, for the hour of 11, alſo 4 *hours* 04 *min.* of the greater Pole, on the greater Contingent Line from C towards D, and 4 *hours* 04 *min.* of the leſſer Pole, on the leſſer Contingent Line from L toward M, for the hour of 10; likewiſe the diſtances of 1 *hour* 04 *min.* and 0 *hour* 4 *min.* from the greater and leſſer Pole, on the greater and leſſer Contingent Lines, from C and L for the hours of 1 and 2. Subtract 4 *min.* from 1 *hour* or 60 *min.* and the remainder 56 *min.* take from the greater, and alſo from the leſſer Pole, and place it on the greater and leſſer Contingent Lines, from C and L towards F and N for the hour of 3; after the ſame manner place the diſtances of 1 *hour* 56 *min.* of 2 *hours* 56 *min.* and of 3 *hours* 56 *min.* taken from the greater and leſſer Pole, or the greater and leſſer Contingent Lines for the hours of 4, 5, and 6; and by theſe Points on both Contingent Lines draw your Hour-lines, and finiſh your Stile and Dial.

If theſe directions be carefully obſerved, you may thereby inlarge any Plane in which the Hour-lines fall too near the Subſtile, by reaſon of the ſmall Elevation of the Stile, whether the ſame be a direct Recliner or Incliner, an upright or Decliner, or an Inclining Decliner, or Reclining Declining Plane.

CHAP. XIX.

How to draw a reflected Dial upon the Cieling of a Room.

THeſe Dials ſhew the Hour of the day by the Sun beams reflected from a piece of poliſhed glaſs, with a bright ſpot among the Hour-lines drawn on the Cieling. The eaſieſt of theſe Dials are thoſe which are reflected from a piece of glaſs, whoſe upper Plane is exactly parallel to the Horizon, but the glaſs may be beſt placed after the Dial is drawn upon the Cieling, therefore we ſhall ſhew you firſt of all how to delineate the ſame, and then to place the glaſs. A Cieling Dial drawn for a Glaſs placed Horizontally is an Horizontal Dial inverted, the Center thereof being in the Meridian Line on the Cieling extended without the Room.

Before you can delineate your Dial, you muſt chuſe a convenient place in the Tranſum or Stroke of the Window to place a ſmall glaſs of $\frac{1}{4}$ of an Inch Diameter, and there making a mark for the Center of your glaſs, proceed to find a Meridian Line iſſuing from that Center as follows. When the Sun ſhines upon the Window, being 3 hours or more before or after 12, faſten a ſmall Packthread from the Center of the glaſs perpendicularly to the Cieling, or to the Frame of the Window, the perpendicularity of the thread may be tried by gently applying the fiducial edge of a Quadrant thereto, or by a plumb-line, then faſten another thread alſo to the ſaid Center

Center, and extend it Horizontally to the oppoſite ſide of the Room, where faſten it ſo, that the ſhadow of the Perpendicular thread may fall thereon, which may be exactly found by applying a white Paſtboard under the Horizontal thread, alſo let there be an Aſſiſtant ready to take the Suns Altitude with a Quadrant, and when you find the ſhadow of the Perpendicular thread to fall preciſely upon the Horizontal thread, at that inſtant let your Aſſiſtant diligently obſerve the Suns Altitude, and note it down; then by the Suns Altitude obſerved, the Latitude of the place and the Declination of the Sun being known, you may find the Suns Azimuth from the Meridian, as hath been already ſhewn; then provide a ſheet of large and ſtiff Paſtboard, upon which deſcribe the Arch of a Circle as large as the Paſtboard will admit, and draw a Line from the Center thereof, repreſenting the Suns Azimuth at the time you took it, then by a Sector, having a Line of Chords iſſuing from the Center, (fitting the Radius of the Arch into the Chord of *60 deg.*) lay the Chord of the Suns Azimuth from the Meridian according to its proper Coaſt, on the Arch drawn on the Paſtboard, from the Line drawn thereon, where the Compaſſes reſt, through that point draw a Line from the Center which repreſents the Meridian Line. Lay this Paſtboard ſo, that the Center of the Circle drawn thereon may agree with the Center of the glaſs, and that the Line drawn on the Paſtboard repreſenting the Suns Azimuth, be placed under the Horizontal thread ſtrained in the Room, and exactly agreeing therewith; this done, faſten the Paſtboard to the Tranſum of the Window Horizontally with ſmall nails, then looſe the Horizontal thread, and bring it exactly over the Meridian Line drawn on the Paſtboard, and faſten it ſo to the oppoſite ſide of the Room Horizontally, and ſo it becomes a Meridian Line; and this Meridian Line may be transferred to the Cieling by a plumb-line applied from ſeveral points in the Cieling, ſo as to touch this thread repreſenting the Meridian, a Line drawn by theſe Points is a Meridian Line on the Cieling, as A B C K in the following Scheme.

Vide Aſtronomical Prob. Book 6.

Now to draw the Hour-lines; extend a thread from the Center of the glaſs at D, to the Point C in the Meridian on the Cieling, ſo that the Line C D may make an Angle of 38 *deg.* $\frac{1}{2}$ with the Meridian, which may be found by applying the fiducial edge of a Quadrant thereto; from the Point C draw C P at right Angles with the Meridian; then meaſure C D, which we will ſuppoſe to be 63 Inches $\frac{1}{10}$, then to find the diſtances C E, C F, C G, *&c.* upon the Line C P for drawing the Hour-lines proceed thus, ſay,

As Radius	And,	*As Radius*
To C D 63 $\frac{1}{10}$		*To* C D 63 $\frac{1}{10}$
So is Tang. 15 *deg. for* 1 *hour*		*So is Tang.* 30 *deg. for* 2 *hours*
To C E 16 $\frac{2}{10}$		*To* C F 38 $\frac{1}{10}$

And ſo for C G, C H, *&c.* as in the Table following the Scheme. Then draw another Line as K O parallel to C P, and ſuppoſe the diſtance C K to be 47 Inches; then to find the diſtances K L, K M, K N, *&c.* firſt find A K, thus,

As the Sine of D A C 51 *deg.* 30 *min.*
To C D 63 $\frac{1}{10}$ *Inches*
So is Radius
To A C 81 *Inches.*

} Which added to C K 47 Inches makes A K 128 Inches.

Then find K S which is parallel to C D, thus,

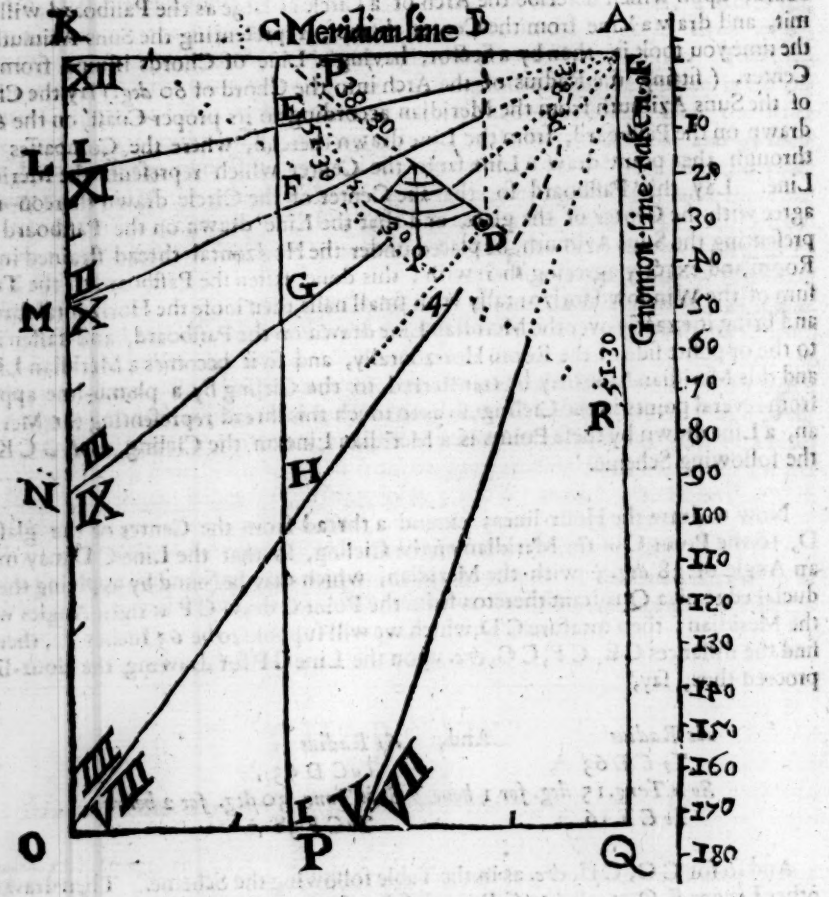
As Radius
To A K 128 *Inches*
So is Sine K A S 51 *d.* 30 *m.*
To K S 101 *Inches.*

Then to find the diſtances K L, K M, K N, *&c.* proceed thus,

Say,
As Radius
To K S 102 Inches
So is Tang. 15 deg. for 1 hour
To K L 26 Inches $\frac{2}{10}$.

And,
As Radius
To K L 101 Inches.
So is Tang. 30 deg. for 2 hours
To K M 57 Inches $\frac{9}{10}$.

And after the same manner find K N, K O, *&c.* as in the aforesaid Table.



The Table.

		Inches.	par.			Inches.	par.
C	E	16	9	K	L	26	8
C	F	38	5	K	M	57	9
C	G	63	3	K	N	101	0
C	H	109	6	K	O	173	6
C	I	236	5	K	P	373	6

Note, You must extend the Lines C P and K O on both sides of the Meridian A K as far as you can, and also set off the distances C E, C F, C G, *&c.* and K L, K M, K O, *&c.* on both sides the said Meridian, and by those Points draw the Hour-lines of 11, 10, 9, *&c.* on the West side of the Meridian, and the hours of 1, 2, 3, *&c.* on the East side of the Meridian, and finish your Dial.

To

To place the glaſs Horizontal, take theſe Directions. When you find it to be near 12 at Noon, by ſome Quadrant or Sun-Dial, fix the glaſs in the hole appointed for it with ſome Putty, as near Horizontal as you can, then with a Quadrant take the Altitude of the Sun, and obſerve the place where the Spot reflected from the glaſs falls on the Cieling, and make a mark there, then extend a thread from the Center of the glaſs to the mark on the Cieling, and apply the fiducial edge of the Quadrant thereto, and thereby find what Angle the ſaid thread makes with the Horizon, which if it be the ſame with the Suns Altitude, the glaſs is well placed, but if it differ therefrom, then you muſt remove the glaſs according to diſcretion, till it agree with the Altitude of the Sun, which you muſt examine by ſeveral trials, and ſo fix it with Putty or Cement.

Note, you muſt rub off the poliſh of the glaſs on the backſide thereof with a Pumice ſtone, or elſe it will reflect a double ſpot.

CHAP. XX.

How to make an Univerſal Dial on a Globe; and to cover it if it be required.

A *Globe*, ſaith *Euclid*, *is made by the Rotation of a Semicircle, keeping the Diameter fixed.* This Dial, if Univerſal, will want the aid of a Magnetical Needle to ſet it, and it muſt move in an Horizon, as the uſual Globes do; whoſe Æquator let be divided into 24 Hours.

You may ſee the Figure on the top of the Dial in the Title of this Seventh Book.

This Globe is to be ſet to the Elevation of the Pole, the hour of 12 being in the Meridian, and hath two Gnomons proportioned to the Polar Circles, which are divided into 24 Hours, and ſerves for a North and South Polar Dial; and to the Poles is fitted a movable Semicircle.

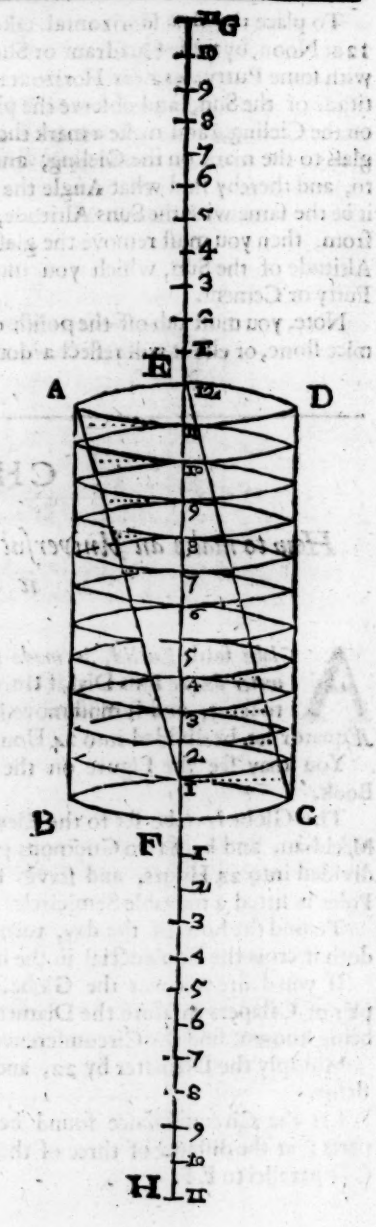
To find the hour of the day, turn the Semicircle till it caſt no ſhadow: Then doth it croſs the Equinoctial in the hour of the day.

If you deſire to cover the Globe, and draw Lines thereon, do it thus: With a pair of Calapers meaſure the Diameter of the Globe you intend to cover; which being known, find the Circumference thus.

Multiply the Diameter by 22, and divide the Product by 7, and you have your deſire.

Let the Circumference found be the Line E F, which divide into 12 equal parts; at the diſtance of three of thoſe parts from E and F draw the Lines A B and C D parallel to E F.

Divide



Divide the Lines E G and F H being of the length of F E, into 12 equal parts; then ſet your Compaſſes at E, and extend them to F, and deſcribe the Arch B C, then ſet your Compaſſes in H, and extend them to 1, and deſcribe the Arch B 1 C; ſo place your Compaſſes in F, and extend them to E, and deſcribe the Arch A E D; then place them in G, and extend them to 11, and deſcribe the Arch A 11 D; and ſo you muſt deſcribe the other Arches. The Segments comprehenders between theſe Arches being cut out with the point of a Pen-knife, and paſted upon the Globe will make a Cover for it.

To Paint and finiſh the Dials, ready to be ſet up in their places.

FOr to faſten the Stile into the Plane, if it be of Wood, you muſt have a ſmall thin Chizel, Gouge, and Gimblet, to let in the Stile, be it round as a rod of Iron, or a piece of Braſs, let in with a Foot an inch and half, more or leſs, as you ſee convenient; and in the Wood make ſuch little Mortiſes as juſt the breadth and length of the foot of the Stile; and if it comes thorow, to clinch on the other ſide, then it is faſt.

If it is in Freeſtone, your Dial drawn firſt in Paper, lay it upon the Plane as it ſhould be; then cut out the Subſtile-line as near its breadth as you can, and only leave ſo much as will juſt hold it together. The Paper laid as before on the Plane, with

with a Black-lead Penſil, or ſuch like, draw the Subſtile Line where it ſtood in the Paper, and with a ſmall Chiſſel make ſuch Mortiſes in that Line as are anſwerable to the foot of the Stile; and crook his Foot, and put it into its place; then with a ſmall Ladle and ſome Lead melted, put the Stile perpendicular with the Plane, and pour in the Lead into the Mortiſe until it is full; and when it is cold, then with a blunt Chiſſel harden the Lead in on each ſide of the Stile or Gnomon: And if the Mortiſe ſhould be too wide, or broken, and not even with the Plane, then wet ſome flower of Alabaſter, (as you may have it fit for that purpoſe at any Maſons) and as ſoon as it is wet make a Plaſter, and ſo ſmooth it, and ſpread it even and plain, and it is preſently dry. Now have you the Stile faſt.

To Paint them, you muſt firſt Prime them: The Prime is made thus. Take an equal quantity of Bole Armoniack and Red Lead, well ground together with Linſeed Oyl, and well rubbed in with a Bruſh or Penſil into the Plane; that being dry, for the outſide colour it is White Lead or Ceruſe well ground together with Linſeed Oyl. Buy the White Lead, and grind it to a Powder, and put it into Water until it become as thick as Pap, and let it dry; then it is for your uſe to grind with Oyl.

For the Hour-lines a Vermilion, and a part Red Lead, well ground together with Lindſeed Oyl, with a ſmall quantity of Oyl of Spike, or Turpentine that will dure, and make the Lines ſhine.

For a Gold Border, rub the Border well with the white Ceruſe; be ſure it be very thick in the Border: Then with Blue Smalts ſtrew very thick the Border while it is wet, and when it is dry, wing that which is looſe off, and ſave it in a Paper.

Take Red Lead and white Lead, as much Red Lead again as White, or Yellow Oker, well ground with Oyl of Spike or Turpentine; this is the Siſe: Then draw with that the Figure you would have in Gold, and when it is ſo dry that it will not come off on your Fingers by a ſlight touch, lay on the Gold; and when it is thorowly dry, wing it off.

How to make a good Black, to ſhadow or make Figures. Grind well with Linſeed Oyl Lamp-black, with ſome Verdigreaſe, and that is a firm Black. The like you may do with all other Colours, as you fancy for ſuch Work.

A Receipt for Red Ink.

FIrſt, Steep one peny-worth of Brazeel Wood all night in Urin; then boil it well and ſtrain it; then bruſe two peny-worth of Cochineel, and boil it, and put in it the bigneſs of a Hens Egg of Roch Allom, that brings it to a colour, and then it is for your turn.

To Paint Freeſtone, waſh the Stone with Oyl, and then all the Colours before may be uſed, as directed.

How to cleanſe a Picture.

TAke blue Smalts, temper it in Water, and rub the Picture with it, and after wipe it with a Linnen Cloth, which Cloth ſhould be dipped in Beer, or otherwiſe with a dry Cloth, and it is clean.

To cleanſe a Gold Border.

WAſh it with Beer, and dry it, and then cleanſe it with Linſeed Oyl.

Maſticous is a fine yellow, ground with ſome Oyl of Spike or Turpentine.

Bice is a good blue Colouring, to be ground with Linſeed Oyl and Red Lead.

And *Spaniſh* Brown will make a laſting Colour for coarſe Work.

To

To grind Gold to Write and Paint.

TAke as many Leaves of Gold as you pleaſe, Honey three or four drops; mix and grind theſe, and keep it in ſome Bone Veſſel. If you will write with it, add ſome Gum-water, and it will be Excellent.

Ovid. lib. Met.

Cuncta fluunt, omniſque vagans formatur Imago.
Ipſa quoque aſſiduo labuntur tempora motu.

All things paſs on: Thoſe Creatures which are made,
Fail, and by Time's aſſiduate motion fade.
Much like the Running Stream, which cannot ſtay,
No more can the light Hours that poſte away.
But as one Billow, haſt'ning to the Shore,
Impels another, and ſtill that before
Is by the following driv'n; ſo we conclude
Of Time, it ſo flies, and is ſo purſu'd.
The Hours are always new; and what hath been
Is never more to be perceiv'd or ſeen:
That daily grows, which had before no ground;
And Minutes, paſt once, never more are found.

Lib. Eleg. 1.

Labitur occulte fallitque volubilis ætas.

The fretting Age deceives, and ſtealing glides;
And the ſwift Year on looſe-rein'd Horſes rides.

Quid non longa dies? Quid non conſumitis Anni?

The End of the Seventh Book.

Some Uſes of the following Tables of Logarithms, Sines, *and* Tangents.

AMongſt the many admirable ways that have been from time to time invented for propagating the Arts Mathematical, and eſpecially that of *Trigonometry*, *Logarithms*, invented by the Right Honourable the Lord *Napier*, Baron of *Marcheſton*, may challenge the priority, and the Tables of *Artificial Sines* and *Tangents*, compoſed by Mr *Edmund Gunter* Profeſſor of Aſtronomy in *Greſham-College*, *London*; for that they expedite the Arithmetical Work in moſt Queſtions; Multiplication being performed by Addition, and Diviſion by Subtraction, the Square Root extracted by Bipartition, and the Cubique Root by Tripartition: So that by help of theſe Numbers. and the aforeſaid *Sines* and *Tangents*, more may be performed in the ſpace of an Hour, than by Natural Numbers, or by Vulgar Arithmetick can be in ſix. Now of what frequent uſe the Doctrine of Triangles, both Plane and Spherical, is in Aſtronomy (for the Reſolution of which the Tables following chiefly ſerve) let the preceded Work teſtifie. And therefore I think it not amiſs here in this place to inſert ſome few Propoſitions, to ſhew the Uſe of the Tables of *Logarithms* and of *Sines* and *Tangents* following.

PROBL. I.

How to find the Logarithms of any Number under 1000.

EVery Page in the Table of *Logarithms* is divided into 11 Columns; in the firſt of which Columns, having the Letter N at the Head thereof, are all Numbers ſucceſſively continued from 1 to 1000: So that to find the *Logarithms* of any Number, is no more but to find the Number in the firſt Column, and in the ſecond Column you ſhall have the *Logarithm* anſwering thereunto.

Example. Let the Number given be 415, and if it is required to find the *Logarithm* thereof, in the Table of *Logarithms*, in the firſt Column thereof, under the Letter N, I find the Number 415, and right againſt it in the next Column I find 618048, which is the *Logarithm* of 415. In the ſame manner you may find the *Logarithm* of any number under 1000; as the *Logarithm* of 506 is 704151, and the *Logarithm* of 900 is 954243, *&c.*

But here is to be noted, That before every *Logarithm* muſt be placed his proper Characteriſtick; *viz.* If the Number conſiſt but of one Figure, as all Numbers under 10, then the Characteriſtick is 0; if the Number conſiſt of two Figures, as all Numbers between 10 and 100, then the Characteriſtick is 1; if the Number conſiſt of three Figures, as all Numbers between 100 and 1000, then the Characteriſtick is 2; and if the Number conſiſts of four Figures, as all between 1000 and 10000, the Characteriſtick muſt be three. In brief, the Characteriſtick of any *Logarithm* muſt conſiſt of an Unit leſs than the given Number hath places: And by obſerving this Rule, the *Logarithm* of 415 will be 2.618048, and the *Logarithm* of 506 is 2.704151, and the *Logarithm* of 900 is 2.954243, *&c.*

PROBL. II.

A Logarithm being given, to find the Abſolute Number thereunto belonging, by the former Obſervation; the Characteriſtick will declare of what Number of Places the Abſolute Number conſiſts.

Example.

LEt the *Logarithm* given be 2.164353; now becauſe the Characteriſtick is 2, I know by it the Abſolute Number conſiſteth of three places, and therefore may be found in the ſecond Column of the *Logarithm* Tables, againſt it I find 146, which is the Abſolute Number anſwering to the *Logarithm* of 2.164353.

PROBL. III.

How to find the Logarithm of a Number that consisteth of four Places.

YOu must find the three first Figures of the given number in the first Column, as before, and seek the last Figure thereof amongst the great Figures in the head of the Page; and in the common Area or meeting of these two Lines is the *Logarithm* you desire, if before it you add or prefix its proper Characteristick.

Example. Let it be required to find the *Logarithm* of 5745; I find 574, the three first Figures, in the first Column, and 5, the last Figure in the head of the Table; then going down from 5 in the head of the Table, untill I come against 574 in the first Column, there I find 759290, before which I place 3 for the Characteristick, and it makes 3.759290, and that is the *Logarithm* sought for.

PROBL. IV.

Any Number of Degrees and Minutes being given, to find the Artificial Sine and Tangent thereof.

ADmit it were required to find the Sine of 21 *deg.* 24 *min.* I turn to the Sines in the Table, and in the head thereof I find Degrees 21; then in the first Column (under M) I find 24, and right against it is 9.562146 for the Sine, and 9.593170 for the Tangent of 21 *deg.* 24 *min.* But suppose it were required to find the Sine or Tangent of 56 *deg.* 35 *min.* Note, all under 45 *deg.* are found in the head, and the odd *min.* in the left hand; and all above 45 *deg.* are found in the foot of the Table, and the *min.* in the last Column towards the right hand; as in this Example the Sine of 56 *deg.* 35 *min.* is 9.921524, and the Tangent is 10.180590.

PROBL. V.

If any Sine or Tangent be given, to find what Degrees and Minutes answer thereunto.

SUppose 9.584663 were a Sine given, I look for the Number in the Table of Sines, and I find it stand against 22 *deg.* 36 *min.* and therefore is the Sine thereof. As admit 9.624330 were a Tangent given, look for the Number in the Column of Tangents, and I find stand against it 22 *deg.* 50 *min.* The same must be done for any other.

Advertiſement.

NOte that the *Inſtruments mentioned in this Book, or any other for the Mathematical Practice, either in Silver, Braſs, or Wood, are accurately made by* Walter Hayes *at the* Croſs daggers *in* Moor-fields, *next door to the* Popes-head Tavern, *where you may be furniſhed with all ſorts of Maps, Globes, Sea-plats, Carpenters Rules, Poſt, and Pocket Dials for any Latitude at reaſonable Rates.*

Advertiſement.

THoſe *moſt famous Cathartique and Diuretique Pills, ſo eminently known to be the only ſafe Medicine againſt the* DROPSIE: *Wherewith was not only Cured his Late Grace* George Duke of Albemarle, *in the year 1669; but many hundreds before and ſince of the aforeſaid Diſtempers, with ſeveral other deſperate Diſeaſes: are ſtill faithfully prepared by* William Sermon *Doctor of Phyſick, one of His Majeſties Phyſicians in Ordinary. Which Pills, beyond any ever yet extant, are certainly found to be the choiceſt Remedy againſt the* SCURVY; *with all other Sharp, Salt, Briniſh, and Watry Humours. They help the Kings Evil, and cauſe all manner of Fiſtula's, Ulcers, Cancers, Leprous Itch, and ſpreading Sores, in what part ſoever, in due time to become whole: They highly ſweeten the Blood; prevent the Meaſels, Small Pox, or Peſtilential Diſeaſes; being the beſt Purge after either: And kills Worms of all ſorts moſt certainly: In order to which is a* Golden Eſſence, *drawn from the whole Maſs or Compoſition, for the benefit of Children that cannot take Pills: Which Pills and Eſſence may not only be had from the Doctors own hands at his Houſe near the Sign of* Goldſmiths-Hall *in* Eaſtharding-ſtreet, *between* Fetter-lane *and* Shoe-lane, London; *but of his truſty Friend Mr.* Edward Thomas *Bookſeller, at the* Adam *and* Eve *in* Little Britain, *and of all others mentioned in the Book given with each Box. And whereas Doctor* Sermon *is often taken for others near his name, as* Salmon, *and* Sherman; *Take notice that he writes his Name* SERMON, *and hath dwelt at the place above-mentioned upwards of Eight years, where he ſtill remains.*

CANON TRIANGULORUM LOGARITHMICUS:

OR, A

TABLE

OF

ARTIFICIAL SINES

AND

TANGENTS

TO

Every DEGREE and MINUTE

OF THE

QUADRANT.

The Common Radius being 10, 000000.

By Capt. SAMUEL STURMY.



London, Printed by *A. Clark*, *Anno Dom.* 1677.

Canon Triangulorum Logarithmicus.

Degree 0					Degree 1				
M	Sine	*Co-sine*	Tangent	*Co-tang.*	Sine	*Co-sine*	Tangent	*Co-tang.*	M
0	0.000000	10.000000	0.000000	*Infinita.*	8.241855	9.999934	8.241921	11.758079	60
1	6.463726	9 999999	6.463726	13.536274	8.249033	9.999932	8.249102	11.750898	59
2	6.764756	9.999999	6.764756	13.235244	8.256094	9.999929	8.256165	11.743835	58
3	6.940847	9.999999	6.940847	13.059153	8.263042	9.999927	8.263115	11.736885	57
4	7.065786	9.999999	7.065786	12.934214	8.269881	9999925	8.269956	11.730044	56
5	7.162696	9.999999	7.162696	12.837304	8.276614	9.999922	8.276691	11.723309	55
6	7.241877	9.999999	7.241878	12.758122	8.283243	9.999920	8.283323	11.716677	54
7	7.308824	9.999999	7.308825	12.691175	8.289773	9.999918	8.289856	11.716144	53
8	7.366816	9.999999	7.366817	12.633183	8.296207	9.999915	8.296292	11.703708	52
9	7.417968	9.999999	7.417970	12.582030	8.302546	9.999913	8.302634	11.697366	51
10	7.463726	9.999998	7.463727	12.536273	8.308794	9.999910	8.308884	11.691116	50
11	7.505118	9.999998	7.505120	12.494880	8.314954	9.999907	8.315046	11.684954	49
12	7.542906	9.999997	7.542909	12.457091	8.321027	9.999905	8.321122	11.678878	48
13	7.577668	9.999997	7.577272	12.422328	8.327016	9.999902	8.327114	11.672886	47
14	7.609853	9.999996	7.609857	12.390143	8.332924	9.999899	8.333025	11.666975	46
15	7.639816	9.999996	7.639826	12.360180	8.338753	9.999897	8.338856	11.661144	45
16	7.667844	9.999995	7.667849	12.332151	8.344504	9.999894	8.344610	11.655390	44
17	7.694173	9.999995	7.694179	12.305821	8.350180	9.999891	8.350289	11.649711	43
18	7.718977	9.999994	7.719003	12.281997	8.355783	9.999888	8.355895	11.644105	42
19	7.742477	9.999993	7.742484	12.257516	8.361315	9.999885	8.361430	11.638570	41
20	7.764754	9.999993	7.764761	12.235239	8.366777	9.999882	8.366895	11.633105	40
21	7.785943	9.999992	7.785951	12.214049	8.372171	9.999879	8.372292	11.627708	39
22	7.806146	9.999991	7.806145	12.193845	8.377499	9.999876	8.377622	11.622378	38
23	7.825451	9.999990	7.825460	12.174540	8.382762	9.999873	8.382889	11.617111	37
24	7.843934	9.999989	7.843944	12.156056	8.387962	9.999870	8.388092	11.611908	36
25	7.861662	9.999989	7.861674	12.138326	8.393101	9.999867	8.393234	11.606766	35
26	7.878695	9.999988	7.878708	12.121292	8.398179	9.999864	8.398315	11.601685	34
27	7.895085	9.999987	7.895099	12.104901	8.403199	9.999861	8.403338	11.596662	33
28	7.910879	9.999986	7.910894	12.089106	8.408161	9.999858	8.408304	11.591696	32
29	7.926119	9.999985	7.926134	12.073866	8.413068	9.999854	8.413213	11.586787	31
30	7.940842	9.999983	7.940858	12.059142	8.417919	9.999851	8.418068	11.581932	30
31	7.955082	9.999982	7.955100	12.044900	8.422717	9.999848	8.422869	11.577131	29
32	7.968870	9.999981	7.968889	12.031111	8.427462	9.999844	8.427618	11.572382	28
33	7.982233	9.999980	7.982253	12.017747	8.432156	9.999841	8.432315	11.567685	27
34	7.995198	9.999978	7.995215	12.004781	8.436800	9.999838	8.436962	11.563038	26
35	8.007787	9.999978	8.007810	11.992191	8.441394	9.999834	8.441560	11.558440	25
36	8.020021	9.999976	8.020044	11.979956	8.445941	9.999831	8.446110	11.553990	24
37	8.031919	9.999975	8.031945	11.968055	8.450440	9.999827	8.450613	11.549387	23
38	8.043501	9.999973	8.043527	11.956473	8.454893	9.999824	8.455070	11.544930	22
39	8.054781	9.999972	8.054809	11.945181	8.459301	9.999820	8.459481	11.540519	21
40	8.065776	9.999971	8.065806	11.934194	8.463665	9.999816	8.463849	11.536151	20
41	8.076500	9.999969	8.076531	11.923469	8.467985	9.999812	8.468172	11.531828	19
42	8.086965	9.999968	8.086997	11.913003	8.472263	9.999809	8.472454	11.527546	18
43	8.097183	9.999966	8.097217	11.902783	8.476498	9.999805	8.476693	11.523307	17
44	8.107167	9.999964	8.107203	11.892797	8.480693	9.999801	8.480892	11.519108	16
45	8.116926	9.999963	8.116963	11.883037	8.484848	9.999797	8 485050	11.514950	15
46	8.126471	9.999961	8.126510	11.873490	8.488963	9.999794	8.489170	11.510830	14
47	8.135810	9.999959	8.135851	11.864149	8.493040	9.999790	8.493250	11.506750	13
48	8.144953	9.999958	8.144996	11.855004	8.497078	9.999786	8.497293	11.502707	12
49	8.153907	9.999956	8.153952	11.846048	8.501080	9.999782	8.501298	11.498702	11
50	8.162681	9.999954	8.162737	11.837273	8.505045	9.999778	8.505267	11.494733	10
51	8.171280	9.999952	8.171328	11.828672	8.508974	9.999774	8.509200	11.490800	9
52	8.179713	9.999950	8.179763	11.820237	8.512867	9.999769	8.513098	11.486902	8
53	8.187985	9.999948	8.188036	11.811964	8.516726	9.999765	8.516961	11.483039	7
54	8.196102	9.999946	8.196156	11.803844	8.520551	9.999761	8.520790	11.479210	6
55	8.204070	9.999944	8.204126	11.795874	8.524343	9.999756	8.524586	11.475414	5
56	8.211895	9.999942	8.211953	11.788047	8.528102	9.999753	8.528349	11.471651	4
57	8.219581	9.999940	8.219641	11.780359	8.531828	9.999748	8.532080	11.467920	3
58	8.227134	9.999938	8 227195	11.772805	8.535523	9.999744	8.535779	11.464221	2
59	8.234557	9.999936	8.234621	11.765379	8.539186	9.999740	8.539447	11.460553	1
60	8.241855	9.999934	8.241921	11.758079	8.542819	9.999735	8.543084	11.456916	0
M	*Co-sine*	Sine	*Co-tang*	Tangent	*Co-sine*	Sine	*Co-tang*	Tangent	M
	Degree 89				Degree 88				

Canon Triangulorum Logarithmicus.

M	Degree 2 Sine	Co-sine	Tangent	Co-tang.
0	8.542819	9.999735	8.543084	11.456916
1	8.546422	9.999731	8.546691	11.453309
2	8.549995	9.999726	8.550268	11.449732
3	8.553558	9.999722	8.553817	11.446183
4	8.557054	9.999717	8.557336	11.442664
5	8.560540	9.999713	8.560827	11.439172
6	8.563959	9.999708	8.564291	11.435709
7	8.567431	9.999703	8.567727	11.432272
8	8.570836	9.999699	8.571137	11.428863
9	8.574214	9.999694	8.574520	11.425480
10	8.577566	9.999689	8.577877	11.422123
11	8.580892	9.999685	8.581208	11.418792
12	8.584193	9.999680	8.584514	11.415486
13	8.587469	9.999675	8.587795	11.412205
14	8.590721	9.999670	8.591051	11.408949
15	8.593948	9.999665	8.594283	11.405717
16	8.597152	9.999660	8.597492	11.402508
17	8.600332	9.999655	8.600977	11.399323
18	8.603488	9.999650	8.603838	11.396161
19	8.606622	9.999645	8.606978	11.393022
20	8.609734	9.999640	8.610094	11.389906
21	8.612823	9.999635	8.613189	11.386811
22	8.615891	9.999629	8.616262	11.383738
23	8.618937	9.999624	8.619313	11.380687
24	8.621967	9.999619	8.622343	11.377657
25	8.624965	9.999614	8.625352	11.374648
26	8.627948	9.999608	8.628340	11.371660
27	8.630911	9.999603	8.631308	11.368692
28	8.633854	9.999597	8.634456	11.365744
29	8.636776	9.999592	8.637184	11.362816
30	8.639679	9.999586	8.640093	11.359907
31	8.642563	9.999581	8.642982	11.357017
32	8.645428	9.999575	8.645853	11.354147
33	8.648274	9.999570	8.648704	11.351296
34	8.651102	9.999564	8.651538	11.348463
35	8.653911	9.999558	8.654352	11.345648
36	8.656702	9.999553	8.657149	11.342851
37	8.659475	9.999547	8.659928	11.340072
38	8.662230	9.999541	8.662689	11.337311
39	8.664968	9.999535	8.665433	11.334567
40	8.667689	9.999529	8.668160	11.331840
41	8.670393	9.999523	8.670869	11.329130
42	8.673080	9.999518	8.673563	11.326437
43	8.675751	9.999512	8.676239	11.323761
44	8.678405	9.999506	8.678899	11.321100
45	8.681043	9.999499	8.681544	11.318456
46	8.683665	9.999493	8.684172	11.315828
47	8.686272	9.999487	8.686784	11.313216
48	8.688892	9.999481	8.689381	11.310619
49	8.691438	9.999475	8.691963	11.308037
50	8.693998	9.999469	8.694529	11.305471
51	8.696543	9.999462	8.697081	11.302919
52	8.699073	9.999456	8.699617	11.300383
53	8.701589	9.999450	8.702139	11.297861
54	8.704090	9.999443	8.704646	11.295354
55	8.706576	9.999437	8.707139	11.292860
56	8.709049	9.999431	8.709618	11.290381
57	8.711507	9.999424	8.712083	11.287917
58	8.713952	9.999418	8.714534	11.285466
59	8.716383	9.999411	8.716972	11.283028
60	8.718800	9.999404	8.719396	11.280604
	Co-sine	Sine	Co-tang.	Tangent

Degree 87

M	Degree 3 Sine	Co-sine	Tangent	Co-tang.
60	8.718800	9.999404	8.719396	11.280604
59	8.721204	9.999398	8.721806	11.278194
58	8.723595	9.999391	8.724254	11.275796
57	8.725972	9.999384	8.726588	11.273412
56	8.728336	9.999378	8.728959	11.271041
55	8.730688	9.999371	8.731317	11.268683
54	8.733027	9.999364	8.733663	11.266337
53	8.735354	9.999357	8.735996	11.264004
52	8.737667	9.999350	8.738317	11.261683
51	8.739969	9.999343	8.740626	11.259374
50	8.742259	9.999336	8.742922	11.257078
49	8.744536	9.999329	8.745207	11.254793
48	8.746801	9.999322	8.747479	11.252521
47	8.745955	9.999315	8.749740	11.250240
46	8.751297	9.999308	8.751989	11.248011
45	8.753528	9.999301	8.754227	11.245773
44	8.755747	9.999294	8.756453	11.243547
43	8.757955	9.999286	8.758668	11.241332
42	8.760151	9.999279	8.760872	11.239128
41	8.762337	9.999272	8.763065	11.236935
40	8.764511	9.999265	8.765246	11.234754
39	8.766675	9.999257	8.767417	11.232583
38	8.768828	9.999250	8.769578	11.230422
37	8.770970	9.999242	8.771727	11.228273
36	8.773101	9.999235	8.773866	11.229134
35	8.775223	9.999227	8.775995	11.224005
34	8.777333	9.999220	8.778114	11.221886
33	8.779434	9.999212	8.783222	11.219778
32	8.781524	9.999204	8.782320	11.217680
31	8.783605	9.999197	8.784404	11.215592
30	8.785675	9.999189	8.786486	11.213514
29	8.787736	9.999181	8.788554	11.211446
28	8.789787	9.999174	8.790613	11.209387
27	8.791828	9.999166	8.792662	11.207338
26	8.793859	9.999158	8.794701	11.205299
25	8.795881	9.999150	8.796731	11.203269
24	8.797894	9.999142	8.798752	11.201248
23	8.799897	9.999134	8.800763	11.199237
22	8.801891	9.999126	8.802765	11.197235
21	8.803876	9.999118	8.804758	11.195242
20	8.805852	9.999110	8.806742	11.193258
19	8.807819	9.999102	8.808717	11.191283
18	8.809777	9.999094	8.812683	11.189317
17	8.811726	9.999086	8.812641	11.187359
16	8.813667	9.999077	8.814589	11.185411
15	8.815598	9.999069	8.816529	11.183471
14	8.817522	9.999061	8.818461	11.181539
13	8.819436	9.999052	8.820384	11.179616
12	8.821342	9.999044	8.822298	11.177702
11	8.823240	9.999036	8.824205	11.175795
10	8.825130	9.999027	8.826103	11.173897
9	8.827011	9.999019	8.827992	11.172008
8	8.828884	9.999010	8.829874	11.170126
7	8.830749	9.999002	8.831748	11.168252
6	8.832106	9.998993	8.833613	11.166387
5	8.834456	9.998984	8.835471	11.164529
4	8.836297	9.998976	8.837321	11.162679
3	8.838130	9.998967	8.839163	11.160837
2	8.839956	9.998958	8.840998	11.159002
1	8.841774	9.998940	8.842825	11.157175
0	8.843585	9.998941	8.844644	11.155356
M	Co-sine	Sine	Co-tang.	Tangent

Degree 86

Canon Triangulorum Logarithmicus.

M	Sine	*Co-sine*	Tangent	*Cotang.*
0	8.843584	9.998941	8.844644	11.155356
1	8.845387	9.998931	8.846455	11.153545
2	8.847183	9.998923	8.848240	11.151740
3	8.848971	9.998914	8.850057	11.149943
4	8.850751	9.998905	8.851846	11.148154
5	8.852525	9.998896	8.853628	11.146372
6	8.854291	9.998887	8.855403	11.144597
7	8.856049	9.998878	8.857171	11.142829
8	8.857801	9.998869	8.858932	11.141068
9	8.859546	9.998860	8.860686	11.139314
10	8.861283	9.998851	8.862433	11.137567
11	8.863014	9.998841	8.864173	11.135827
12	8.864738	9.998832	8.865906	11.134094
13	8.866454	9.998823	8.867632	11.132368
14	8.868165	9.998813	8.869351	11.130649
15	8.869868	9.998804	8.871064	11.128936
16	8.871565	9.998795	8.872750	11.127230
17	8.873255	9.998785	8.874469	11.125531
18	8.874938	9.998776	8.876162	11.123838
19	8.876615	9.998766	8.877849	11.122151
20	8.878285	9.998757	8.879529	11.120471
21	8.879949	9.998747	8.881202	11.118798
22	8.881607	9.998738	8.882869	11.117131
23	8.883258	9.998728	8.884530	11.115470
24	8.884903	9.998718	8.886185	11.113815
25	8.886542	9.998708	8.887833	11.112167
26	8.888174	9.998699	8.889476	11.110524
27	8.889801	9.998685	8.891112	11.108888
28	8.891421	9.998679	8.892742	11.107258
29	8.893035	9.998669	8.894366	11.105634
30	8.894643	9.998659	8.895984	11.104016
31	8.896246	9.998649	8.897596	11.102404
32	8.897842	9.998639	8.899203	11.100797
33	8.899432	9.998629	8.900803	11.099199
34	8.901017	9.998619	8.902398	11.097602
35	8.902596	9.998609	8.903987	11.096013
36	8.904169	9.998599	8.905570	11.094430
37	8.905736	9.998589	8.907147	11.092853
38	8.907297	9.998577	8.908719	11.091281
39	8.908853	9.998568	8.910285	11.089715
40	8.910404	9.998558	8.911846	11.088154
41	8.911949	9.998548	8.913401	11.086599
42	8.913488	9.998537	8.914951	11.085049
43	8.915022	9.998527	8.916495	11.083505
44	8.916550	9.998516	8.918034	11.081966
45	8.918073	9.998506	8.919568	11.080432
46	8.919591	9.998495	8.921096	11.078904
47	8.921103	9.998485	8.922619	11.077381
48	8.922610	9.998474	8.924136	11.075864
49	8.924112	9.998464	8.925649	11.074351
50	8.925609	9.998453	8.927156	11.072844
51	8.927100	9.998442	8.928658	11.071342
52	8.928587	9.998431	8.930155	11.069845
53	8.930068	9.998421	8.931647	11.068353
54	8.931544	9.998410	8.933134	11.066866
55	8.933015	9.998399	8.934616	11.065384
56	8.934481	9.998388	8.936093	11.063907
57	8.935942	9.998377	8.937565	11.062435
58	8.937398	9.998366	8.939032	11.060968
59	8.938850	9.998355	8.940494	11.059506
60	8.940296	9.998344	8.941952	11.058048
	Cosine	Sine	*Co-tang.*	Tangent

Degree 85

Degree 4

Sine	*Co-sine*	Tangent	*Co-tang.*	
8.940296	9.998344	8.941952	11.058048	60
8.941738	9.998333	8.943404	11.056596	59
8.943174	9.998322	8.944852	11.055148	58
8.944606	9.998311	8.946295	11.053705	57
8.946034	9.998300	8.947734	11.052266	56
8.957456	9.998289	8.949168	11.050832	55
8.958814	9.998277	8.950597	11.049403	54
8.950287	9.998266	8.952021	11.047979	53
8.951696	9.998255	8.953441	11.046559	52
8.953099	9.998243	8.954856	11.045144	51
8.954499	9.998232	8.956267	11.043733	50
8.955894	9.998220	8.957674	11.042326	49
8.957284	9.998209	8.959075	11 040925	48
8.958670	9.998197	8.960473	11.039527	47
8.960052	9.998186	8.961866	11.038134	46
8.961429	9.998174	8.963254	11.036746	45
8.962801	9.998163	8.964639	11.035361	44
8.964170	9.998151	8.966019	11.033981	43
8.965534	9.998139	8.967394	11.032606	42
8.966893	9.998128	8.968766	11.031234	41
8.968249	9.998106	8.970133	11.029867	40
8.969600	9.998104	8.971495	11.028505	39
8.970947	9.998092	8 972855	11.027145	38
8.972289	9.998080	8.974209	11.025791	37
8.973626	9.998068	8.975560	11.024440	36
8.974961	9.998056	8.976906	11.023094	35
8.976293	9.998044	8.978248	11.021752	34
8.977619	9.998032	8.979586	11.020414	33
8.978941	9.998020	8.980921	11.019079	32
8.980259	9.998008	8.982251	11.017749	31
8.981573	9 997996	8.983577	11.016423	30
8.982883	9.997984	8.984899	11.015101	29
8.984189	9.997971	8.986217	11.013783	28
8.985491	9.997959	8.987532	11.012468	27
8.986789	9.997947	8.988842	11.011158	26
8.988083	9.997935	8.990149	11.009851	25
8.989374	9.997922	8.991451	11.008549	24
8.990660	9.997910	8.992750	11.007250	23
8.991943	9.997897	8.994045	11.005955	22
8.993228	9 997885	8.995337	11.004663	21
8.994497	9.997873	8.996624	11.003376	20
8.995768	9.997860	8.997908	11.002092	19
8.997036	9.997847	8.999188	11.000812	18
8.998299	9.997835	9.000465	10.999535	17
8.999560	9.997822	9.001738	10.998262	16
9.000816	9.997809	9.003007	10.996993	15
9.002069	9.997797	9.004272	10.995728	14
9.003318	9.997784	9.005534	10.994466	13
9.004563	9 997771	9.006792	10.993208	12
9.005805	9.997758	9.008047	10.991953	11
9.007044	9.997732	9.009298	10.990702	10
9.008278	9.997732	9.010546	10.989454	9
9.009510	9.997719	9.011790	10.988210	8
9.010737	9.997706	9.013031	10.986969	7
9.011962	9.997693	9.014268	10.985732	6
9.013182	9.997680	9.015502	10.984498	5
9.014399	9.997667	9.016732	10.983268	4
9.015613	9.997654	9.017959	10.982041	3
9.016824	9.997641	9.019183	10.980817	2
9.018031	9.997628	9.020403	10.979597	1
9.019235	9.997614	9.021620	10.978380	0
Co-sine	Sine	*Co-tang*	Tangent	M

Degree 84

Degree 5

Canon Triangulorum Logarithmicus.

Degree 6					Degree 7				
M.	Sine	*Co-sine*	Tangent	*Co-tang.*	Sine	*Co-sine*	Tangent	*Co-tang.*	
0	9.019235	9.997614	9.021620	10.978380	9.085894	9.996751	9.089144	10.910856	60
1	9.020435	9.997601	9.022834	10.977166	9.086922	9.996735	9.090187	10.909813	59
2	9.021632	9.997588	9.024044	10.975956	9.087947	9.996720	9.091228	10.908772	58
3	9.022825	9.997574	9.025251	10.974749	9.088970	9.996704	9.092266	10.907734	57
4	9.024016	9.997561	9.026455	10.973545	9.089990	9.996688	9.093302	10.906698	56
5	9.025203	9.997548	9.027655	10.972345	9.091088	9.996673	9.094336	10.905664	55
6	9.026386	9.997534	9.028852	10.971148	9.092024	9.996657	9.095367	10.904633	54
7	9.027567	9.997520	9.030046	10.969954	9.093037	9.996641	9.096395	10.903604	53
8	9.028744	9.997507	9.031237	10.968763	9.094047	9.996625	9.097422	10.902578	52
9	9.029918	9.997493	9.032425	10.967575	9.095056	9.996610	9.098446	10.901554	51
10	9.031089	9.997480	9.033609	10.966391	9.096062	9 996594	9.099468	10.900532	50
11	9.032257	9.997466	9.034791	10.965209	9.097065	9.996578	9.100487	10.899513	49
12	9.033421	9.997452	9.035969	10.964031	9.098066	9.996562	9.101504	10.898496	48
13	9.034582	9.997439	9.037144	10.962856	9.099065	9.996546	9.102519	10.897481	47
14	9.035741	9.997425	9.038316	10.961684	9.100062	9.996530	9.103532	10.896468	46
15	9.036896	9.997411	9.039485	10.960515	9.101056	9.996514	9.104541	10.895458	45
16	9.038048	9.997397	9.040651	10.959349	9.102048	9.996498	9.105550	10.894450	44
17	9.039197	9.997383	9.041813	10.958187	9.103037	9.996482	9.106556	10.893444	43
18	9.040342	9.997369	9.042973	10.957027	9.104025	9.996465	9.107559	10.892441	42
19	9.041485	9.997355	9.044130	10.955870	9.105010	9.996449	9.108560	10.891440	41
20	9.042625	9.997341	9.045284	10.954716	9.105992	9.996433	9.109559	10.890441	40
21	9.043762	9.997327	9.046434	10.953566	9.106973	9.996417	9.110556	10.889444	39
22	9.044895	9.997313	9.047582	10.952418	9.107951	9.996400	9.111551	10.888449	38
23	9.046026	9.997299	9.048727	10.951273	9.108927	9.996384	9.112543	10.887457	37
24	9.047154	9.997285	9.049869	10.950131	9.109901	9.996368	9.113533	10.886467	36
25	9.048279	9.997271	9.051008	10.948992	9.110873	9.996351	9.114521	10.885478	35
26	9.049400	9.997256	9.052144	10.947856	9.111842	9.996335	9.115507	10.884493	34
27	9.050519	9.997242	9.053277	10.946723	9.112809	9.996318	9.116491	10.883509	33
28	9.051635	9.997228	9.054408	10.945592	9.113774	9.996302	9.117472	10.882528	32
29	9.052749	9.997214	9.055535	10.944465	9.114737	9.996285	9.118452	10.881548	31
30	9.053859	9.997199	9.056640	10.943340	9.115698	9.996269	9.119429	10.880571	30
31	9.054966	9.997185	9.057781	10.942219	9.116656	9.996252	9.120404	10.879596	29
32	9.056071	9.997170	9.058900	10.941100	9.116612	9.996235	9.121377	10.878623	28
33	9.057172	9.997156	9.060016	10.939984	9.118567	9.996218	9.122348	10.877652	27
34	9.058271	9.997141	9.061130	10.938870	9.119519	9.996202	9.123317	10.876683	26
35	9.059367	9.997127	9.062240	10.937760	9.120469	9.996185	9.124284	10.875716	25
36	9.060460	9.997112	9.063348	10.936652	9.121417	9.996168	9.125248	10.874751	24
37	9.061551	9 997098	9.064453	10.935547	9.122362	9.996151	9.126211	10.873789	23
38	9.062638	9.997083	9.065556	10.934444	9.123306	9.996134	9.127172	10.872828	22
39	9.063723	9.997068	9.066655	10.933345	9.124248	9.996117	9.128130	10.871870	21
40	9.064806	9.997053	9.067752	10.932248	9.125187	9.996100	9.129087	10.870913	20
41	9.065885	9.997039	9.068847	10.931153	9.126125	9.996083	9.130041	10.869959	19
42	9.066962	9.997024	9.069938	10.930062	9.127060	9.996066	9.130994	10.869006	18
43	9.068036	9.997009	9.071027	10.928973	9.127993	9.996049	9.131944	10.868056	17
44	9.069107	9.996994	9.072113	10.927887	9.128925	9.996032	9.132893	10.867107	16
45	9.070176	9.996979	9.073197	10.926803	9.129854	9.996015	9.133839	10.866161	15
46	9.071242	9.996964	9.074278	10.925722	9.130781	9.995998	9.134784	10.865216	14
47	9.072306	9.996949	9.075356	10.924644	9.131706	9.995980	9.135726	10.864274	13
48	9.073366	9.996934	9.076432	10.923568	9.132630	9.995963	9.136666	10.863334	12
49	9.074424	9.996919	9.077505	10.922495	9.133551	9.995946	9.137605	10.862395	11
50	9.075480	9.996904	9.078576	10.921424	9.134470	9.995928	9.138542	10.861458	10
51	9.076533	9.996889	9.079644	10.920356	9.135387	9.995911	9.139476	10.860524	9
52	9.077583	9.996874	9.080710	10.919290	9.136303	9.995894	9.140409	10.859591	8
53	9.078631	9.996858	9.081773	10.918227	9.137216	9.995876	9.141340	10.858660	7
54	9.079676	9.996843	9.082833	10.917167	9.138127	9.995859	9.142269	10.857731	6
55	9.080719	9.996828	9.083891	10.916109	9.139037	9.995841	9.143196	10.856804	5
56	9.081759	9.996812	9.084947	10.915053	9.139944	9.995825	9.144121	10.855879	4
57	9.082797	9.996797	9.085999	10.914000	9.140850	9.995806	9.145044	10.854956	3
58	9.083832	9.996782	9.087050	10.912950	9.141754	9.995788	9.145965	10.854035	2
59	9.084864	9.996766	9.088098	10.911902	9.142655	9.995770	9.146885	10.853115	1
60	9.085894	9.996751	9.089144	10.910856	9.142555	9.995753	9.147803	10.852197	0
	Co-sine.	Sine	*Co-tang.*	Tangent	*Co-sine*	Sine	*Co-tang.*	Tangent	M.
	Degree 83.				Degree 82				

Canon Triangulorum Logarithmicus.

Degree 8.

M	Sine	*Co-sine*	Tangent	*Co-tang.*
0	9.143555	9.995753	9.147803	10.852197
1	9.144453	9.995735	9.148718	10.851282
2	9.145349	9.995717	9.149632	10.850368
3	9.146243	9.995699	9.150544	10.849456
4	9.147136	9.995681	9.151454	10.848546
5	9.148026	9.995664	9.152363	10.847637
6	9.148915	9.995646	9.153269	10.846731
7	9.149801	9.995628	9.154174	10.845825
8	9.150686	9.995610	9.155077	10.844923
9	9.151569	9.995591	9.155978	10.844022
10	9.152451	9.995573	9.156877	10.843123
11	9.153330	9.995555	9.157775	10.842225
12	9.154208	9.995537	9.158671	10.841329
13	9.155082	9.995519	9.159565	10.840435
14	9.155957	9.995501	9.160457	10.839543
15	9.156830	9.995482	9.161347	10.838653
16	9.157700	9.995464	9.162236	10.837764
17	9.158569	9.995446	9.163123	10.836877
18	9.159436	9.995427	9.164008	10.835992
19	9.160301	9.995409	9.164892	10.835108
20	9.161164	9.995390	9.165773	10.834226
21	9.162025	9.995372	9.166654	10.833346
22	9.162885	9.995353	9.167532	10.832468
23	9.163743	9.995334	9.168409	10.831591
24	9.164600	9.995316	9.169284	10.830716
25	9.165454	9.995297	9.170157	10.829843
26	9.166307	9.995278	9.171029	10.828971
27	9.167158	9.995260	9.171899	10.828101
28	9.168008	9.995241	9.172767	10.827233
29	9.168856	9.995222	9.173634	10.826366
30	9.169702	9.995203	9.174499	10.825501
31	9.170546	9.995184	9.175362	10.824638
32	9.171389	9.995165	9.176224	10.823776
33	9.172230	9.995146	9.177084	10.822916
34	9.173070	9.995127	9.177942	10.822057
35	9.173908	9.995108	9.178799	10.821201
36	9.174744	9.995089	9.179655	10.820345
37	9.175578	9.995070	9.180508	10.819492
38	9.176411	9.995061	9.181360	10.818640
39	9.177242	9.995032	9.182211	10.817789
40	9.178072	9.995012	9.183060	10.816940
41	9.178900	9.994993	9.183907	10.816093
42	9.179726	9.994974	9.184752	10.815248
43	9.180551	9.994955	9.185597	10.814403
44	9.181374	9.994935	9.186439	10.813561
45	9.182196	9.994916	9.187280	10.812720
46	9.183016	9.994896	9.188120	10.811880
47	9.183834	9.994876	9.188957	10.811042
48	9.184651	9.994857	9.189794	10.810206
49	9.185466	9.994838	9.190629	10.809371
50	9.186280	9.994818	9.191462	10.808538
51	9.187092	9.994798	9.192294	10.807706
52	9.187903	9.994779	9.193124	10.806876
53	9.188712	9.994759	9.193953	10.806047
54	9.189519	9.994739	9.194780	10.805220
55	9.190325	9.994719	9.195606	10.804394
56	9.191130	9.994699	9.196440	10.803569
57	9.191933	9.994680	9.197253	10.802747
58	9.192734	9.994660	9.198074	10.801926
59	9.193534	9.994640	9.198894	10.801106
60	9.194332	9.994620	9.199712	10.800287
	Co-sine	Sine	*Co-tang.*	Tangent

Degree 81.

Degree 9.

Sine	*Co-sine*	Tangent	*Co-tang.*	
9.194332	9.994620	9.199712	10.800287	60
9.195129	9.994600	9.200529	10.799470	59
9.195925	9.994580	9.201345	10.798655	58
9.196718	9.994560	9.202159	10.797841	57
9.197511	9.994540	9.202971	10.797029	56
9.198302	9.994519	9.203782	10.796218	55
9.199091	9.994499	9.204592	10.795408	54
9.199879	9.994479	9.205400	10.794600	53
9.200666	9.994459	9.206207	10.793793	52
9.201451	9.994438	9.207013	10.792987	51
9.202234	9.994418	9.207817	10.792183	50
9.203017	9.994398	9.208619	10.791381	49
9.203797	9.994377	9.209420	10.790580	48
9.204577	9.994357	9.210220	10.789780	47
9.205354	9.994336	9.211018	10.788982	46
9.206131	9.994316	9.211815	10.788185	45
9.206906	9.994295	9.212611	10.787389	44
9.207679	9.994274	9.213405	10.786595	43
9.208452	9.994254	9.214198	10.785802	42
9.209222	9.994233	9.214989	10.785011	41
9.209992	9.994212	9.215780	10.784220	40
9.210760	9.994191	9.216568	10.783432	39
9.211526	9.994171	9.217356	10.782644	38
9.212291	9.994150	9.218142	10.781858	37
9.213055	9.994129	9.218926	10.781074	36
9.213818	9.994108	9.219710	10.780290	35
9.214579	9.994087	9.220491	10.779508	34
9.215338	9.994066	9.221272	10.778728	33
9.216097	9.994044	9.222052	10.777948	32
9.216854	9.994024	9.222830	10.777170	31
9.217609	9.994003	9.223607	10.776393	30
9.218363	9.993982	9.224382	10.775618	29
9.219116	9.993960	9.225156	10.774844	28
9.219868	9.993939	9.225929	10.774071	27
9.220618	9.993918	9.226704	10.773300	26
9.221367	9.993897	9.227471	10.772529	25
9.222115	9.993875	9.228240	10.771760	24
9.222861	9.993854	9.229007	10.770993	23
9.223606	9.993832	9.229774	10.770226	22
9.224349	9.993811	9.230539	10.769461	21
9.225092	9.993789	9.231302	10.768698	20
9.225833	9.993768	9.232065	10.767935	19
9.226573	9.993746	9.232826	10.767174	18
9.227311	9.993725	9.233586	10.766414	17
9.228048	9.993703	9.234345	10.765655	16
9.228784	9.993681	9.235103	10.764897	15
9.229518	9.993660	9.235859	10.764141	14
9.230252	9.993638	9.236614	10.763386	13
9.230984	9.993616	9.237368	10.762632	12
9.231715	9.993594	9.238120	10.761880	11
9.232444	9.993572	9.238872	10.761128	10
9.233172	9.993550	9.239622	10.760378	9
9.233899	9.993528	9.240371	10.759629	8
9.234625	9.993506	9.241118	10.758882	7
9.235349	9.993484	9.241865	10.758135	6
9.236073	9.993462	9.242610	10.757390	5
9.236795	9.993440	9.243354	10.756646	4
9.237515	9.993418	9.244097	10.755903	3
9.238835	9.993396	9.244839	10.755161	2
9.238952	9.993374	9.245579	10.754421	1
9.239670	9.993351	9.246319	10.753681	0
Co-sine	Sine	*Co-tang.*	Tangent	M

Degree 80.

Canon Triangulorum Logarithmicus.

Degree 10.				
M	Sine	*Co-sine*	Tangent	*Co-tang.*
0	9.239670	9.993351	9.246319	10.753681
1	9.240386	9.993329	9.247057	10.752943
2	9.241101	9.993329	9.247794	10.752206
3	9.241814	9.993284	9.248530	10.751470
4	9.242526	9.993262	9.249264	10.750736
5	9.243237	9.993240	9.249998	10.750002
6	9.243947	9.993117	9.250730	10.749270
7	9.244656	9.993195	9.251461	10.748539
8	9.245363	9.993172	9.252191	10.747809
9	9.246070	9.993149	9.252920	10.747080
10	9.246775	9.993127	9.253648	10.746352
11	9.247478	9.993104	9.254374	10.745626
12	9.248181	9.993011	9.255200	10.744900
13	9.248883	9.993059	9.255824	10.744176
14	9.249583	9.993036	9.256547	10.743453
15	9.250282	9.993013	9.257269	10.742731
16	9.250980	9.992990	9.257990	10.742010
17	9.251677	9.992967	9.258710	10.741290
18	9.252373	9.992944	9.259429	10.740571
19	9.253067	9.992921	9.260146	10.739854
20	9.253761	9.992898	9.260863	10.739137
21	9.254453	9.992875	8.261578	10.738422
22	9.255144	9.992852	8.262292	10.737708
23	9.255834	9.992829	8.263005	10.736995
24	9.256523	9.992806	8.263717	10.736283
25	9.257211	9.992783	8.264428	10.735572
26	9.257898	9.992759	9.265138	10.734862
27	9.258583	9.992736	9.265847	10.734153
28	9.259268	9.992713	9.266555	10.733445
29	9.259951	9.992690	9.267261	10.732739
30	9.260633	9.992666	9.267967	10.732033
31	9.261314	9.992643	9.268671	10.731329
32	9.261994	9.992619	9.269375	10.730625
33	9.262673	9.992596	9.270078	10.729923
34	9.263351	9.992572	9.271479	10.729221
35	9.264027	9.992549	9.271479	10.728521
36	9.264703	9.992525	9.272178	10.727822
37	9.265378	9.992501	9.272876	10.727124
38	9.266051	9.992478	9.273573	10.726427
39	9.266723	9.992454	9.274269	10.725731
40	9.267395	9.992430	9.274964	10.725036
41	9.268065	9.992406	9.275658	10.724342
42	9.268734	9.992382	9.276351	10.723649
43	9.269402	9.992362	9.277043	10.722957
44	9.270069	9.992335	9.277734	10.722267
45	9.270735	9.992311	9.278424	10.721576
46	9.271400	9.992287	9.279113	10.720887
47	9.272063	9.992263	9.279801	10.720199
48	9.272726	9.992239	9.280488	10.719512
49	9.273388	9.992214	9.281174	10.718826
50	9.274049	9.992190	9.281858	10.718142
51	9.274708	9.992166	9.282541	10.717458
52	9.275367	9.992142	9.283225	10.716775
53	9.276025	9.992118	9.283907	10.716093
54	9.276681	9.992093	9.284588	10.715412
55	9.277337	9.992069	9.285268	10.714732
56	9.277991	9.992045	9.285946	10.714053
57	9.278685	9.992020	9.286624	10.713376
58	9.279297	9.991996	9.287301	10.712699
59	9.279948	9.991971	9.287977	10.712023
60	9.280599	9.991947	9.288652	10.711348
	Co-sine	Sine	*Co-tang.*	Tangent

Degree 79.

Degree 11				
Sine	*Co-sine*	Tangent	*Co-tang.*	
9.280599	9.991947	9.288652	10.711348	60
9.281229	9.991922	9.289326	10.710674	59
9.281897	9.991897	9.289999	10.710001	58
9.282544	9.991873	9.290671	10.709329	57
9.283190	9.991848	9.291342	10.708658	56
9.283836	9.991823	9.292013	10.707987	55
9.284480	9.991799	9.292682	10.707318	54
9.285124	9.991774	9.293350	10.706650	53
9.285766	9.991749	9.294017	10.705983	52
9.286408	9.991724	9.294684	10.705316	51
9.287048	9.991699	9.295349	10.704651	50
9.287688	9 991674	9.296013	10.703987	49
9.288326	9.991649	9.296677	10.703323	48
9.288964	9.991624	9.297339	10.702661	47
9.289600	9.991599	9.298001	10.701999	46
9.290236	9.991574	9.298662	10.701338	45
9.290870	9.991549	9.299322	10.700678	44
9.291504	9.991524	9.299980	10.700020	43
9.292137	9.991498	9.300638	10.699362	42
9.292768	9.991473	9.301295	10.698705	41
9.293399	9.991448	9.301951	10.698049	40
9.294029	9.991422	9.302607	10.697393	39
9.294658	9.991397	9.303261	10.696739	38
9.295286	9.991372	9.303914	10.696086	37
9.295913	9.991346	9.304567	10.695433	36
9.296539	9.991321	9.305218	10.694782	35
9.297164	9.991295	9.305867	10.694131	34
9.297788	9.991270	9.306519	10.693481	33
9.298412	9.991244	9.307168	10.692832	32
9.299024	9.991218	9 307816	10.692184	31
9.299655	9.991193	9.308463	10.691537	30
9.300276	9.991167	9.309109	10.690891	29
9.300895	9.991141	9.309754	10.690246	28
9.301514	9.991115	9.310399	10.689601	27
9.302132	9.991090	9.311042	10.688958	26
9.302749	9.991064	9.311685	10.688315	25
9.303364	9.991038	9.312327	10.687673	24
9.303979	9.991012	9.312968	10.687032	23
9.304593	9.990986	9.313608	10.686392	22
9.305207	9.990960	9.314247	10.685753	21
9.305819	9.990934	9.314885	10.685115	20
9.306430	9.990908	9.315523	10.684477	19
9.307041	9.990882	9.316159	10.683841	18
9.307650	9.990855	9.316795	10.683205	17
9.308259	9.990829	9.317430	10.682570	16
9.308867	9.990803	9.318064	10.681936	15
9.309474	9.990777	9.318697	10.681303	14
9.310080	9.990750	9.319330	10.680670	13
9.310685	9.990724	9.319961	10.680039	12
9.311289	9.990697	9.320592	10.679408	11
9.311899	9.990671	9.321222	10.678778	10
9.312495	9.990645	9.321851	10.678149	9
9.313097	9.990618	9.322479	10.677521	8
9.313698	9.990591	9.323106	10.676894	7
9.314297	9.990565	9.323733	10.676267	6
9.314897	9.990538	9.324358	10.675642	5
9.315495	9.990512	9.324983	10.675017	4
9.316092	9.990485	9.325607	10.674393	3
9.316689	9.990458	9.326231	10.673769	2
9.317284	9.990431	9.326853	10.673147	1
9.317879	9.990404	9.327475	10.672525	0
Co-sine	Sine	*Co-tang.*	Tangent	M

Degree 78.

Canon Triangulorum Logarithmicus.

Degree 12.				
M	Sine	*Co-sine*	Tangent	*Co-tang.*
0	9.317879	9.990404	9.327475	10.672525
1	9.318473	9.990377	9.328095	10.671905
2	9.319066	9.990351	9.328715	10.671285
3	9.319658	9.990324	9.329334	10.670666
4	9.320250	9.990297	9.329953	10.670047
5	9.320840	9.990270	9.320570	10.669430
6	9.321430	9.990242	9.331187	10.668813
7	9.322019	9.990215	9.331803	10.668197
8	9.322607	9.990188	9.332418	10.667582
9	9.323194	9.990161	9.333033	10.666967
10	9.323780	9.990134	9.333646	10.666354
11	9.324366	9.990107	9.334259	10.665741
12	9.324950	9.990079	9.334871	10.665129
13	9.325534	9.990052	9.335482	10.664518
14	9.326117	9.990025	9.336093	10.663907
15	9.326699	9.989997	9.336703	10.663298
16	9.327281	9.989970	9.337311	10.662689
17	9.327862	9.989942	9.337919	10.662081
18	9.328441	9.989915	9.338527	10.661473
19	9.329020	9.989887	9.339133	10.660867
20	9.329599	9.989860	9.339739	10.660261
21	9.330176	9.989832	9.340344	10.659656
22	9.330753	9.989804	9.340948	10.659052
23	9.331328	9.989777	9.341552	10.658448
24	9.331903	9.989749	9.342155	10.657845
25	9.332478	9.989721	9.342757	10.657243
26	9.333051	9.989693	9.343358	10.656642
27	9.333624	9.989665	9.343958	10.656042
28	9.334195	9.989637	9.344558	10.655442
29	9.334766	9.989609	9.345157	10.654843
30	9.335337	9.989581	9.345755	10.654245
31	9.335906	9.989553	9.346353	10.653647
32	9.336475	9.989525	9.346949	10.653051
33	9.337043	9.989597	9.347545	10.652455
34	9.337610	9.989469	9.348141	10.651859
35	9.338176	9.989441	9.348735	10.651265
36	9.338742	9.989413	9.349329	10.650671
37	9.339306	9.989384	9.349922	10.650078
38	9.339870	9.989356	9.350514	10.649486
39	9.340434	9.989328	9.351106	10.648894
40	9.340996	9.989299	9.351697	10.648303
41	9.341558	9.989271	9.352287	10.647713
42	9.342119	9.989243	9.352876	10.647124
43	9.342679	9.989214	9.353465	10.646535
44	9.343239	9.989186	9.354053	10.645947
45	9.343797	9.989157	9.354640	10.645360
46	9.344355	9.989128	9.355227	10.644773
47	9.344912	9.989100	9.355812	10.644187
48	9.345469	9.989071	9.356398	10.643602
49	9.346024	9.989042	9.356982	10.643018
50	9.346579	9.989014	9.357566	10.642434
51	9.347134	9.988985	9.358149	10.641851
52	9.347687	9.988956	9.358731	10.641269
53	9.348240	9.988927	9.359313	10.640687
54	9.348792	9.988898	9.359893	10.640107
55	9.349343	9.988869	9.360474	10.639526
56	9.349893	9.988840	9.361053	10.638947
57	9.350443	9.988811	9.361632	10.638368
58	9.350992	9.988782	9.362210	10.637790
59	9.351540	9.988754	9.362787	10.637213
60	9.352088	9.988724	9.363364	10.636636
	Co-sine	Sine	*Co-tang.*	Tangent
Degree 77.				

Degree 13.				
Sine	*Co-sine*	Tangent	*Co-tang.*	
9.352088	9.988724	9.363364	10.636636	60
9.352635	9.988695	9.363940	10.636060	59
9.353181	9.988666	9.364515	10.635485	58
9.353726	9.988636	9.365090	10.634910	57
9.354271	9.988607	9.365664	10.634336	56
9.354185	9.988578	9.366237	10.633763	55
9.355358	9.988548	9.366810	10.633190	54
9.355901	9.988519	9.367382	10.632618	53
9.356443	9.988489	9.367953	10.632047	52
9.356984	9.988460	9.368524	10.631476	51
9.357524	9.988430	9.369094	10.630906	50
9.358064	9.988401	9.369663	10.630337	49
9.358603	9.988371	9.370232	10.629768	48
9.359141	9.988341	9.370799	10.629201	47
9.359679	9.988312	9.371367	10.628633	46
9.350215	9.988282	9.371933	10.628067	45
9.360752	9.988252	9.372499	10.627501	44
9.361287	9.988223	9.373064	10.626936	43
9.361822	9.988193	9.373629	10.626371	42
9.362356	9.988163	9.374193	10.625807	41
9.362889	9.988133	9.374756	10.625244	40
9.363422	9.988103	9 375319	10.624681	39
9.363954	9.988073	9.375881	10.624119	38
9.364485	9.988043	9.376442	10.623558	37
9.365016	9.988013	9.377003	10.622997	36
9.365546	9.987983	9.377563	10.622437	35
9.366075	9.987953	9.378122	10.621878	34
9.366604	9.987922	9.378681	10.621319	33
9.367132	9.987892	9.379239	10.620761	32
9.367659	9.987862	9.379797	10.620203	31
9.368185	9.987832	9.380354	10.619646	30
9.368711	9.987801	9.380910	10.619090	29
9.369236	9.987771	9.381466	10.618534	28
9.369761	9.987740	9 382021	10.617980	27
9.370285	9.987710	9.382575	10.617425	26
9.370808	9.987679	9 383129	10.616871	25
9.371330	9.987649	9.383682	10.616318	24
9.371852	9.987618	9.384234	10.615766	23
9.372373	9.987588	9.384786	10.615214	22
9.372894	9.987557	9.385337	10.614663	21
9.373414	9.987526	9.385888	10.614112	20
9.373933	9.987496	9.386438	10.613562	19
9.374452	9.987465	9.386987	10.613013	18
9.374970	9.987434	9.387536	10.612464	17
9.375487	9.987403	9.388084	10.611916	16
9.376003	9.987372	9.388631	10.611369	15
9.376519	9.987341	9.389178	10.610822	14
9.377035	9.987310	9.389724	10.610276	13
9.377549	9.987279	9.390270	10.609730	12
9.378063	9.987248	9.390815	10.609185	11
9.378577	9.987217	9.391360	10.608640	10
9.379089	9.987186	9.391907	10.608097	9
9.379601	9.987155	9.392467	10.607553	8
9.380113	9.987124	9.392989	10.607011	7
9.380624	9.987092	9.393531	10.606469	6
9.381134	9.987061	9.394074	10.605927	5
9.381643	9.987030	9.394614	10.605386	4
9.382152	9.986998	9.395154	10.604846	3
9.382661	9.986967	9.395694	10.604306	2
9.383168	9.986936	9.396233	10.603767	1
9.383675	9.986904	9.396771	10.603229	0
Co-sine	Sine	*Co-tang.*	Tangent	M
Degree 76.				

Canon Triangulorum Logarithmicus.

Degree 14.

M	Sine	*Co-sine*	Tangent	*Co-tang.*
0	9.383675	9.986904	9.396771	10.603229
1	9.384181	9.986873	9.397309	10.602694
2	9.384687	9.986841	9.397846	10.602154
3	9.385192	9.986809	9.398383	10.601617
4	9.385697	9.986778	9.398919	10.601081
5	9.386201	9.986746	9.399455	10.600545
6	9.386704	9.986714	9.399990	10.600010
7	9.387207	9.986683	9.400524	10.599476
8	9.387709	9.986651	9.401058	10.598942
9	9.388210	9.986619	9.401591	10.598409
10	9.388711	9.986587	9.402124	10.597876
11	9.389211	9.986555	9.402656	10.597344
12	9.389711	9.986523	9.403187	10.596813
13	9.390210	9.986491	9.403718	10.596282
14	9.390708	9.986459	9.404249	10.595751
15	9.391206	9.986427	9.404778	10.595222
16	9.391703	9.986395	9.405306	10.594692
17	9.392199	9.986363	9.405836	10.594164
18	9.392695	9.986331	9.406364	10.593636
19	9.393190	9.986299	9.406892	10.593108
20	9.393685	9.986266	9.407419	10.592581
21	9.394179	9.986234	9.407945	10.592055
22	9.394673	9.986201	9.408471	10.591529
23	9.395166	9.986169	9.408996	10.591001
24	9.395654	9.986137	9.409521	10.590479
25	9.396150	9.986104	9.410045	10.589954
26	9.396641	9.986072	9.410569	10.589431
27	9.397131	9.986039	9.411092	10.588908
28	9.397621	9.986007	9.411615	10.588385
29	9.398111	9.985974	9.412137	10.587863
30	9.398600	9.985942	9.412658	10.587342
31	9.399087	9.985909	9.413179	10.586821
32	9.399575	9.985876	9.413699	10.586301
33	9.400062	9.985843	9.414219	10.585781
34	9.400549	9.985811	9.414738	10.585262
35	9.401035	9.985778	9.415257	10.584742
36	9.401520	9.985745	9.415775	10.584225
37	9.402005	9.985712	9.416293	10.583707
38	9.402489	9.985679	9.416810	10.583190
39	9.402972	9.985646	9.417326	10.582674
40	9.403455	9.985613	9.417842	10.582157
41	9.403938	9.985580	9.418357	10.581642
42	9.404420	9.985547	9.418873	10.581127
43	9.404901	9.985513	9.419387	10.580613
44	9.405382	9.985480	9.419901	10.580099
45	9.405862	9.985447	9.420415	10.579585
46	9.406341	9.985414	9.420927	10.579072
47	9.406820	9.985380	9.421440	10.578560
48	9.407299	9.985347	9.421951	10.578048
49	9.407776	9.985314	9.422463	10.577537
50	9.408254	9.985280	9.422973	10.577026
51	9.408731	9.985247	9.423484	10.576516
52	9.409207	9.985213	9.423993	10.576007
53	9.409682	9.985180	9.424503	10.575497
54	9.410157	9.985146	9.425011	10.574989
55	9.410632	9.985112	9.425518	10.574480
56	9.411106	9.985079	9.426027	10.573973
57	9.411579	9.985045	9.426534	10.573466
58	9.412052	9.985011	9.427041	10.572959
59	9.412524	9.984977	9.427547	10.572453
60	9.412996	9.984943	9.428052	10.571947

Co-sine	Sine	*Co-tang.*	Tangent

Degree 75.

Degree 15.

Sine	*Co-sine*	Tangent	*Co-tang.*	
9.412996	9.984944	9.428052	10.571947	60
9.413467	9.984910	9.428557	10.571442	59
9.413938	9.984876	9.429062	10.570938	58
9.414408	9.984842	9.429566	10.570434	57
9.414878	9.984808	9.430070	10.569930	56
9.415347	9.984774	9.430573	10.569427	55
9.415815	9.984740	9.431075	10.568925	54
9.416283	9.984706	9.431577	10.568423	53
9.416850	9.984672	9.432079	10.567921	52
9.417217	9.984637	9.432580	10.567420	51
9.417684	9.984603	9.433080	10.566920	50
9.418149	9.984569	9.433580	10.566419	49
9.418615	9.984535	9.434080	10.565920	48
9.419079	9.984500	9.434579	10.565421	47
9.419544	9.984466	9.435078	10.564922	46
9.420007	9.984431	9.435576	10.564424	45
9.420470	9.984397	9.436073	10.563927	44
9.420933	9.984363	9.436570	10.563430	43
9.421395	9.984328	9.437067	10.562933	42
9.421856	9.984293	9.437563	10.562437	41
9.422317	9.984259	9.438059	10.561941	40
9.422778	9.984224	9.438554	10.561446	39
9.423238	9.984189	9.439048	10.560952	38
9.423697	9.984155	9.439543	10.560457	37
9.424156	9.984120	9.440036	10.559964	36
9.424615	9.984085	9.440529	10.559471	35
9.425072	9.984050	9.441022	10.558978	34
9.425530	9.984015	9.441514	10.558486	33
9.425987	9.983980	9.442006	10.557994	32
9.426443	9.983945	9.442497	10.557503	31
9.426899	9.983910	9.442988	10.557011	30
9.427354	9.983875	9.443479	10.556521	29
9.427809	9.983840	9.443968	10.556031	28
9.428264	9.983805	9.444458	10.555542	27
9.428717	9.983770	9.444947	10.555053	26
9.429170	9.983735	9.445435	10.554565	25
9.429623	9.983699	9.445923	10.554077	24
9.430075	9.983664	9.446411	10.553589	23
9.430507	9.983626	9.446898	10.553102	22
9.430978	9.983593	9.447384	10.552616	21
9.431429	9.983558	9.447870	10.552120	20
9.431879	9.983523	9.448356	10.551644	19
9.432328	9.983487	9.448841	10.551159	18
9.432778	9.983452	9.449326	10.550674	17
9.433206	9.983416	9.449870	10.550181	16
9.433674	9.983380	9.450294	10.549706	15
9.434122	9.983345	9.450777	10.549223	14
9.434569	9.983309	9.451260	10.548740	13
9.435016	9.983273	9.451743	10.548257	12
9.435462	9.983238	9.452225	10.547775	11
9.435918	9.983202	9.452706	10.547294	10
9.436353	9.983166	9.453187	10.546813	9
9.436798	9.983130	9.453668	10.546332	8
9.437242	9.983094	9.454148	10.545852	7
9.437686	9.983058	9.454629	10.545372	6
9.438129	9.983022	9.455107	10.544893	5
9.438572	9.982986	9.455586	10.544414	4
9.439014	9.982950	9.456064	10.543936	3
9.439456	9.982914	9.456542	10.543458	2
9.439897	9.982878	9.457019	10.542980	1
9.440338	9.982842	9.457496	10.542503	0

Co-sine	Sine	*Co-tang.*	Tangent	M

Degree 74.

Canon Triangulorum Logarithmicus.

Degree 16.

M	Sine	Co-sine	Tangent	Co-tang.
0	9.440338	9.982842	9.457496	10.542503
1	9.440773	9.982805	9.457973	10.542027
2	9.441218	9.982769	9.458449	10.541551
3	9.441658	9.982733	9.458925	10.541075
4	9.442096	9.982696	9.459400	10.540600
5	9.442535	9.982660	9.459875	10.540125
6	9.442973	9.982623	9.460349	10.539651
7	9.443416	9.982587	9.460829	10.539177
8	9.443848	9.982550	9.461297	10.538703
9	9.444284	9.982514	9.461770	10.538230
10	9.444720	9.982477	9.462242	10.537758
11	9.445155	9.982441	9.462714	10.537285
12	9.445590	9.982404	9.463186	10.536814
13	9.446025	9.982367	9.463658	10.536342
14	9.446459	9.982330	9.464129	10.535871
15	9.446893	9.982294	9.464599	10.535401
16	9.447326	9.982257	9.465069	10.534931
17	9.447759	9.982220	9.465539	10.534461
18	9.448191	9.982183	9.466008	10.533992
19	9.448623	9.982146	9.466476	10.533523
20	9.449054	9.982109	9.466945	10.533055
21	9.449485	9.982072	9.467413	10.532587
22	9.449915	9.982035	9.467880	10.532120
23	9.450345	9.981998	9.468347	10.531653
24	9.450775	9.981961	9.468814	10.531186
25	9.451203	9.981923	9.469280	10.530720
26	9.451632	9.981886	9.469746	10.530253
27	9.452060	9.981849	9.470211	10.529789
28	9.452488	9.981812	9.470676	10.529324
29	9.452915	9.981774	9.471141	10.528859
30	9.453342	9.981737	9.471605	10.528395
31	9.453768	9.981699	9.472068	10.527931
32	9.454194	9.981662	9.472532	10.527468
33	9.454619	9.981624	9.472995	10.527005
34	9.455044	9.981587	9.473457	10.526543
35	9.455469	9.981549	9.473919	10.526081
36	9.455892	9.981512	9.474381	10.525619
37	9.456316	9.981474	9.474842	10.525153
38	9.456739	9.981436	9.475303	10.524695
39	9.457162	9.981398	9.475763	10.524237
40	9.457584	9.981361	9.476223	10.523777
41	9.458006	9.981323	9.476683	10.523317
42	9.458427	9.981285	9.477142	10.522858
43	9.458848	9.981247	9.477601	10.522395
44	9.459268	9.981209	9.478059	10.521941
45	9.459684	9.981171	9.478517	10.521483
46	9.460108	9.981133	9.478975	10.521025
47	9.460527	9.981095	9.479432	10.520568
48	9.460946	9.981057	9.479886	10.520111
49	9.461364	9.981019	9.480345	10.519655
50	9.461782	9.980980	9.480801	10.519199
51	9.462199	9.980942	9.481257	10.518743
52	9.462616	9.980904	9.481712	10.518288
53	9.463032	9.980866	9.482167	10.517833
54	9.463448	9.980827	9.482621	10.517375
55	9.463864	9.980789	9.483075	10.516925
56	9.464279	9.980750	9.483528	10.516471
57	9.464694	9.980712	9.483982	10.516018
58	9.465108	9.980672	9.484434	10.515565
59	9.465522	9.980635	9.484887	10.515113
60	9.465935	9.980596	9.485339	10.514661
	Co-sine	Sine	Co-tang.	Tangent

Degree 73.

Degree 17.

Sine	Co-sine	Tangent	Co-tang.	
9.465935	9.980596	9.485339	10.514661	60
9.466348	9.980558	9.485791	10.514209	59
9.466761	9.980519	9.486242	10.513758	58
9.467173	9.980480	9.486693	10.513307	57
9.467585	9.980441	9.487143	10.512857	56
9.467996	9.980403	9.487593	10.512407	55
9.468407	9.980364	9.488043	10.511957	54
9.468817	9.980325	9.488493	10.511507	53
9.469227	9.980286	9.488941	10.511059	52
9.469637	9.980247	9.489390	10.510610	51
9.460446	9.980208	9.489838	10.510162	50
9.470455	9.980169	9.490286	10.509714	49
9.471863	9.980130	9.490733	10.509267	48
9.471071	9.980091	9.491180	10.508820	47
9.471678	9.980052	9.491627	10.508373	46
9.472086	9.980012	9.492073	10.507918	45
9.472492	9.979973	9.492519	10.507481	44
9.472898	9.979934	9.492964	10.507035	43
9.473304	9.979894	9.493410	10.506590	42
9.473710	9.979855	9.493854	10.506145	41
9.474115	9.979816	9.494299	10.505701	40
9.474519	9.979776	9.494743	10.505257	39
9.474923	9.979737	9.495186	10.504813	38
9.475327	9.979697	9.495630	10.504370	37
9.475730	9.979658	9.496073	10.503928	36
9.476133	9.979618	9.496515	10.503485	35
9.476536	9.979578	9.496957	10.503043	34
9.476938	9.979539	9.497399	10.502601	33
9.477340	9.979499	9.497840	10.502160	32
9.477741	9.979459	9.498282	10.501718	31
9.478142	9.979419	9.498722	10.501278	30
9.478542	9.979380	9.499163	10.500837	29
9.478942	9.979340	9.499602	10.500398	28
9.479342	9.979300	9.500042	10.499958	27
9.479741	9.979260	9.500481	10.499519	26
9.480140	9.979220	9.500920	10.499080	25
9.480538	9.979180	9.501359	10.498641	24
9.480936	9.979140	9.501797	10.498203	23
9.481334	9.979099	9.502234	10.497766	22
9.481731	9.979059	9.502672	10.497328	21
9.482128	9.979019	9.503109	10.496891	20
9.482525	9.978980	9.503546	10.496454	19
9.482921	9.978939	9.503982	10.496018	18
9.483316	9.978898	9.504418	10.495582	17
9.483711	9.978858	9.504854	10.495146	16
9.484106	9.978817	9.505289	10.494711	15
9.484501	9.978777	9.505724	10.494216	14
9.484895	9.978736	9.506158	10.493841	13
9.485289	9.978696	9.506593	10.493407	12
9.485682	9.978655	9.507026	10.492973	11
9.486075	9.978615	9.507459	10.492540	10
9.486467	9.978574	9.507892	10.492107	9
9.486859	9.978533	9.508326	10.491674	8
9.487251	9.978493	9.508759	10.491241	7
9.487642	9.978452	9.509181	10.490809	6
9.488033	9.978411	9.509622	10.490377	5
9.488424	9.978370	9.510044	10.489946	4
9.488814	9.978329	9.510486	10.489515	3
9.489204	9.978288	9.510916	10.489084	2
9.489593	9.978247	9.511346	10.488654	1
9.489982	9.978206	9.511776	10.488225	0
Co-sine	Sine	Co-tang.	Tangent	M

Degree 70.

Canon Triangulorum Logarithmicus.

M	Sine	Co-sine	Tangent	Co-tang.
0	9.489982	9.978206	9.511776	10.488224
1	9.490371	9.978165	9.512206	10.487794
2	9.490759	9.978124	9.512635	10.487365
3	9.491147	9.978083	9.513064	10.486936
4	9.491534	9.978042	9.513493	10.486507
5	9.491922	9.978000	9.513921	10.486079
6	9.492308	9.977959	9.514349	10.485651
7	9.492695	9.977918	9.514777	10.485223
8	9.493080	9.977877	9.515204	10.484796
9	9.493466	9.977835	9.515631	10.484369
10	9.493851	9.977794	9.516057	10.483942
11	9.494236	9.977752	9.516484	10.483516
12	9.494620	9.977711	9.516910	10.483090
13	9.495005	9.977669	9.517335	10.482665
14	9.495388	9.977628	9.517761	10.482239
15	9.495771	9.977586	9.518185	10.481814
16	9.496154	9.977544	9.518610	10.481390
17	9.496537	9.977503	9.519034	10.480966
18	9.496919	9.977461	9.519458	10.480542
19	9.497301	9.977419	9.519882	10.480118
20	9.497682	9.977377	9.520305	10.479695
21	9.498063	9.977335	9.520728	10.479272
22	9.498444	9.977293	9.521151	10.478849
23	9.498824	9.977251	9.521573	10.478427
24	9.499204	9.977209	9.521995	10.478005
25	9.499584	9.977167	9.522417	10.477583
26	9.499963	9.977125	9.522838	10.477162
27	9.500342	9.977083	9.523259	10.476741
28	9.500720	9.977041	9.523679	10.476320
29	9.501099	9.976999	9.524099	10.475900
30	9.501476	9.976956	9.524520	10.475480
31	9.501854	9.976914	9.524939	10.475060
32	9.502231	9.976872	9.525359	10.474641
33	9.502607	9.976830	9.525778	10.474222
34	9.502984	9.976787	9.526197	10.473803
35	9.503360	9.976745	9.526615	10.473385
36	9.503735	9.976702	9.527033	10.472967
37	9.504110	9.976660	9.527451	10.472549
38	9.504485	9.976617	9.527868	10.472132
39	9.504840	9.976574	9.528285	10.471715
40	9.505234	9.976532	9.528701	10.471298
41	9.505608	9.976489	9.529118	10.470882
42	9.505981	9.976446	9.529535	10.470465
43	9.506354	9.976404	9.529950	10.470049
44	9.506727	9.976361	9.530366	10.469634
45	9.507099	9.976318	9.530781	10.469219
46	9.507471	9.976275	9.531196	10.468804
47	9.507843	9.976232	9.531611	10.468389
48	9.508214	9.976185	9.532025	10.467975
49	9.508585	9.976146	9.532436	10.467561
50	9.508955	9.976103	9.532852	10.467147
51	9.509326	9.976060	9.533266	10.466734
52	9.509696	9.976017	9.533679	10.466321
53	9.510065	9.975973	9.534091	10.465908
54	9.510434	9.975930	9.534504	10.465496
55	9.510803	9.975887	9.534916	10.465084
56	9.511171	9.975844	9.535328	10.464672
57	9.511540	9.975800	9.535739	10.464261
58	9.511907	9.975757	9.536150	10.463849
59	9.512275	9.975713	9.536561	10.463439
60	9.512642	9.975670	9.536972	10.463028
	Co-sine.	Sine	Co-tang.	Tangent

Degree 71.

Degree 18.

Sine	Co-sine	Tangent	Co-tang.	
9.512642	9.975670	9.536972	10.463028	60
9.513009	9.975626	9.537382	10.462618	59
9.513375	9.975583	9.537792	10.462208	58
9.513741	9.975539	9.538202	10.461798	57
9.514107	9.975496	9.538610	10.461389	56
9.514472	9.975452	9.539020	10.460980	55
9.514837	9.975408	9.539429	10.460571	54
9.515202	9.975364	9.539837	10.460163	53
9.515566	9.975321	9.540245	10.459755	52
9.515930	9.975277	9.540653	10.459347	51
9.516294	9.975233	9.541061	10.458939	50
9.516657	9.975189	9.541468	10.458532	49
9.517020	9.975145	9.541875	10.458125	48
9.517382	9.975101	9.542281	10.457719	47
9.517745	9.975057	9.542688	10.457312	46
9.518107	9.975013	9.543094	10.456906	45
9.518468	9.974969	9.543499	10.456501	44
9.518829	9.974925	9.543905	10.456095	43
9.519190	9.974880	9.544310	10.455690	42
9.519551	9.974836	9.544715	10.455285	41
9.519911	9.974792	9.545110	10.454881	40
9.520271	9.974747	9.545524	10.454476	39
9.520631	9.974703	9.545927	10.454072	38
9.520990	9.974659	9.546331	10.453669	37
9.521349	9.974614	9.546735	10.453265	36
9.521707	9.974570	9.547138	10.452862	35
9.522065	9.974525	9.547540	10.452459	34
9.522423	9.974480	9.547943	10.452057	33
9.522781	9.974436	9.548345	10.451655	32
9.523138	9.974391	9.548747	10.451253	31
9.523495	9.974346	9.549149	10.450851	30
9.523851	9.974302	9.549550	10.450450	29
9.524208	9.974257	9.549951	10.450049	28
9.524564	9.974212	9.550352	10.449648	27
9.524920	9.974167	9.550752	10.449248	26
9.525275	9.974122	9.551152	10.448848	25
9.525630	9.974077	9.551552	10.448448	24
9.525984	9.974032	9.551952	10.448048	23
9.526339	9.973987	9.552351	10.447649	22
9.526693	9.973942	9.552750	10.447250	21
9.527046	9.973897	9.553149	10.446851	20
9.527400	9.973852	9.553548	10.446452	19
9.527753	9.973807	9.553946	10.446054	18
9.528105	9.973761	9.554344	10.445656	17
9.528458	9.973716	9.554741	10.445259	16
9.528810	9.973671	9.555139	10.444861	15
9.529161	9.973625	9.555536	10.444464	14
9.529513	9.973580	9.555932	10.444068	13
9.529864	9.973535	9.556329	10.443671	12
9.530214	9.973489	9.556725	10.443275	11
9.530565	9.973443	9.557121	10.442879	10
9.530915	9.973398	9.557517	10.442483	9
9.531265	9.973352	9.557912	10.442088	8
9.531614	9.973307	9.558308	10.441693	7
9.531963	9.973261	9.558702	10.441298	6
9.532312	9.973215	9.559097	10.440903	5
9.532661	9.973169	9.559491	10.440509	4
9.533009	9.973123	9.559885	10.440115	3
9.533357	9.973078	9.560279	10.439721	2
9.533704	9.973032	9.560673	10.439327	1
9.534051	9.972986	9.561066	10.438934	0
Co-sine	Sine	Co-tang.	Tangent	M

Degree 19.

Degree 70.

Canon Triangulorum Logarithmicus.

M	Degree 20. Sine	Co-sine	Tangent	Co-tang.
0	9.534052	9.972986	9.561066	10.438934
1	9.534399	9.972940	9.561459	10.438541
2	9.534746	9.972894	9.561851	10.438148
3	9.535091	9.972848	9.562244	10.437756
4	9.535437	9.972801	9.562636	10.437364
5	9.535782	9.972755	9.563028	10.436972
6	9.536129	9.972709	9.563419	10.436580
7	9.536474	9.972663	9.563811	10.436189
8	9.536818	9.972617	9.564202	10.435798
9	9.537163	9.972570	9.564592	10.435407
10	9.537507	9.972524	9.564983	10.435017
11	9.537851	9.972477	9.565373	10.434627
12	9.538194	9.972431	9.565763	10.434237
13	9.538537	9 972384	9.566153	10.433847
14	9.538880	9.972338	9.566542	10.433457
15	9.539222	9.972291	9.566932	10.433068
16	9.539565	9.972245	9.567320	10.432679
17	9.539907	9.972198	9.567709	10.432291
18	9.540249	9.972151	9.568097	10.431902
19	9.540590	9.972105	9.568486	10.431514
20	9.540931	9.972058	9.569873	10.431126
21	9.541272	9.972011	9 569261	10.430739
22	9.541612	9.971964	9.569648	10.430351
23	9.541953	9.971917	9.560035	10.429964
24	9.542292	9.971870	9.560422	10.429578
25	9.542632	9.971823	9.560809	10.429191
26	9.542971	9.971776	9.571195	10.428805
27	9.543310	9.971729	9.571581	10.428419
28	9.543649	9.971682	9.571967	10.428033
29	9.543987	9.971635	9.572352	10.427648
30	9.544325	9.971588	9.572738	10.427262
31	9.544663	9.971540	9.573123	10.426877
32	9.545000	9.971493	9.573507	10.426492
33	9.545338	9.971446	9.573892	10.426108
34	9.545674	9.971398	9.574276	10.425724
35	9.546011	9.971351	9.574660	10.425340
36	9.546347	9.971303	9.575044	10.424956
37	9.546683	9.971256	9.575427	10.424572
38	9 547019	9.971208	9.575810	10.424189
39	9.547354	9.971161	9.576193	10.423807
40	9.547689	9.971112	9.576576	10.423424
41	9.548024	9.971065	9.576958	10.423041
42	9.548358	9.971018	9.577341	10.422659
43	9.548693	9.970970	9.577723	10.422277
44	9.549026	9.970922	9.578104	10.421896
45	9.549360	9.970874	9.578486	10.421514
46	9.549693	9.970826	9.578867	10.421133
47	9.550026	9.970779	9.579248	10.420752
48	9.550359	9.970731	9.579628	10.420371
49	9.550692	9.970683	9.580009	10.419991
50	9.551024	9.970634	9.580389	10.419611
51	9.551355	9.970586	9.580769	10.419231
52	9.551687	9.970538	9.581149	10.418851
53	9.552018	9.970490	9.581528	10.418472
54	9.552349	9.970442	9.581907	10.418092
55	9.552680	9.970394	9.582286	10.417713
56	9.553010	9.970345	9.582665	10.417335
57	9.553340	9.970297	9.583043	10.416956
58	9.553670	9.970249	9.583422	10.416578
59	9.554000	9.970200	9.583800	10.416200
60	9.554329	9.970152	9.584177	10.415823
	Co-sine	Sine	Co-tang.	Tangent

Degree 69.

Degree 21. Sine	Co-sine	Tangent	Co-tang.	
9.554329	9.970152	9.584177	10.415822	60
9.554658	9.970103	9.584555	10.415445	65
9.554987	9.970055	9.584932	10.415068	58
9.555315	9.970006	9.585308	10.414691	57
9.555643	9.969957	9.585686	10.414314	56
9.555971	9.969909	9.586062	10.413938	55
9.556299	9.969860	9.586439	10.413561	54
9.556626	9.969811	9.586815	10.413185	53
9.556953	9.969762	9.587190	10.412800	52
9.557279	9.969713	9.587566	10.412434	51
9.557606	9.969665	9.587941	10.412059	50
9.557932	9.969616	9.588316	10.411684	49
9.558258	9.969567	9.588691	10.411309	48
9.558583	9.969518	9.589066	10.410934	47
9.558909	9.969469	9.589440	10.410560	46
9.559234	9.969419	9.589814	10.410185	45
9.559558	9.969370	9.590188	10.409812	44
9.559883	9.969321	9.590561	10.409438	43
9.560207	9.969272	9.590935	10.409065	42
9.560531	9.969223	9.591308	10.408692	41
9.560855	9.969173	9.591681	10.408319	40
9.561178	9.969124	9.592054	10.407946	39
9.561501	9.969075	9.592426	10.407574	38
9.561824	9.969025	9.592798	10.407201	37
9.562146	9.968976	9.593170	10.406829	36
9.562468	9.968926	9.593542	10.406457	35
9.562790	9.968877	9.593194	10.406086	34
9.563112	9.968827	9.594285	10.405715	33
9.563433	9.968777	9.594656	10.405344	32
9.563754	9.968728	9.595027	10.405073	31
9.564075	9.968678	9.595397	10.404602	30
9.564396	9.968628	9.595768	10.404232	29
9.564716	9.968578	9.596138	10.403862	28
9.565036	9.968528	9.596508	10.403492	27
9.565356	9.968478	9.596878	10.403122	26
9.565675	9.968428	9.597247	10.402753	25
9.565995	9.968378	9 597616	10.402384	24
9.566314	9.968328	9.597985	10.402015	23
9.566632	9.968278	9.598354	10.401646	22
9.566951	9 968228	9.598722	10.401277	21
9.567269	9.968178	9.599091	10.400909	20
9.567587	9.968128	9.599459	10.400541	19
9.567904	9.968078	9.599827	10.400173	18
9.568222	9.968027	9.600194	10.399806	17
9.568539	9.967977	9.600562	10.399438	16
9.568855	9.967927	9.600929	10.399071	15
9.569172	9.967876	9.601296	10.398704	14
9.569488	9.967826	9.601662	10.398337	13
9.569804	9.967775	9.602029	10.397971	12
9.570120	9.967725	9.602395	10.397605	11
9.570435	9.967674	9.602761	10.397239	10
9.570751	9.967623	9.603127	10.396873	9
9.571065	9.967573	9.603493	10.396507	8
9.571380	9.967522	9.603858	10.396142	7
9.571695	9.967471	9.604223	10.395777	6
9.572009	9 967420	9.604588	10.395412	5
9.572322	9.967370	9.604953	10.395047	4
9.572636	9.967319	9.605317	10.394683	3
9.572949	9.967268	9.605681	10.394318	2
9.573263	9.967217	9.606046	10.393954	1
9.573575	9.967166	9.606409	10.393590	0
Co-sine	Sine	Co-tang.	Tangent	M

Degree 68.

Canon Triangulorum Logarithmicus.

M	Degree 22. Sine	*Co-fine*	Tangent	*Co-tang.*
0	9.573575	9.967166	9.606409	10.393590
1	9.573883	9.967115	9.606773	10.393227
2	9.574200	9.967064	9.607136	10.392863
3	9.574512	9.967012	9.607500	10.392500
4	9.574824	9.966961	9.607862	10.392137
5	9.575135	9.966910	9.608225	10.391774
6	9.575447	9.966859	9.608588	10.391412
7	9.575758	9.966807	9.608950	10.391050
8	9.576068	9.966756	9.609312	10.390688
9	9.576379	9.966705	9.609674	10.390326
10	9.576689	9.966653	9.610036	10.389964
11	9.576999	9.966602	9.610397	10.389603
12	9.577309	9.966550	9.610758	10.389241
13	9.577618	9.966499	9.611119	10.388880
14	9.577927	9.966447	9.611480	10.388520
15	9.578236	9.966395	9.611841	10.388159
16	9.578545	9.966344	9.612201	10.387799
17	9.578853	9.966292	9.612561	10.387438
18	9.579161	9.966240	9.612921	10.387078
19	9.579469	9.966188	9.613281	10.386719
20	9.579777	9.966136	9.613641	10.386359
21	9.580084	9.966084	9.614000	10.386000
22	9.580392	9.966032	9.614359	10.385641
23	9.580698	9.965980	9.614718	10.385282
24	9.581005	9.965928	9.615077	10.384923
25	9.581311	9.965876	9.615435	10.384565
26	9.581618	9.965824	9.615793	10.384207
27	9.581923	9.965772	9.616151	10.383448
28	9.582229	9.965720	9.616509	10.383491
29	9.582534	9.965668	9.616867	10.383133
30	9.582840	9.965615	9.617224	10.382776
31	9.583144	9.965563	9.617581	10.382418
32	9.583449	9.965511	9.617938	10.382061
33	9.583753	9.965458	9.618295	10.381705
34	9.584058	9.965406	9.618652	10.381348
35	9.584361	9.965353	9.619008	10.380992
36	9.584665	9.965301	9.619364	10.380635
37	9.584968	9.965248	9.619720	10.380279
38	9.585271	9.965195	9.620076	10.379924
39	9.585574	9.965143	9.620432	10.379568
40	9.585877	9.965090	9.620787	10.379213
41	9.586179	9.965037	9.621142	10.378858
42	9.586481	9.964984	9.621497	10.378503
43	9.586783	9.964931	9.621852	10.378148
44	9.587085	9.964878	9.622206	10.377793
45	9.587386	9.964825	9.622561	10.377439
46	9.587687	9.964772	9.622915	10.377085
47	9.587988	9.964719	9.623269	10.376731
48	9.588289	9.964666	9.623623	10.376377
49	9.588589	9.964613	9.623976	10.376024
50	9.588890	9.964560	9.624330	10.375670
51	9.589190	9.964507	9.624683	10.375317
52	9.589489	9.964454	9.625036	10.374964
53	9.589789	9.964400	9.625388	10.374612
54	9.590088	9.964347	9.625741	10.374259
55	9.590387	9.964294	9.626093	10.373907
56	9.590686	9.964240	9.626445	10.373555
57	9.590984	9.964187	9.626797	10.373203
58	9.591282	9.964133	9.627149	10.372850
59	9.591580	9.964080	9.627501	10.372499
60	9.591878	9.964026	9.627852	10.372148
	Co-fine	Sine	*Co-tang.*	Tangent

Degree 67.

Degree 23. Sine	*Co-fine*	Tangent	*Co-tang.*	
9.591878	9.964026	9.627852	10.372148	60
9.592175	9.963972	9.628203	10.371797	59
9.592473	9.963919	9.628554	10.371446	58
9.592770	9.963865	9.628905	10.371095	57
9.593067	9.963811	9.629255	10.370744	56
9.593363	9.963757	9.629606	10.370394	55
9.593659	9.963703	9.629956	10.370044	54
9.593955	9.963650	9.630306	10.369694	53
9.594251	9.963596	9.630655	10.369344	52
9.594547	9.963542	9.631005	10.368995	51
9.594842	9.963488	9.631354	10.368645	50
9.595137	9.963433	9.631704	10.368296	49
9.595432	9.963379	9.632053	10.367947	48
9.595727	9.963325	9.632401	10.367598	47
9.596021	9.963271	9.632750	10.367250	46
9.596315	9.963217	9.633098	10.366901	45
9.596610	9.963102	9.633447	10.366553	44
9.596903	9.963108	9.633795	10.366205	43
9.597196	9.963054	9.634143	10.365857	42
9.597490	9.962999	9.634490	10.365510	41
9.597783	9.962945	9.634838	10.365162	40
9.598075	9.962892	9.635185	10.364815	39
9.598368	9.962836	9.635530	10.364468	38
9.598660	9.962781	9.635879	10.364121	37
9.598952	9.962726	9.636226	10.363774	36
9.599244	9.962672	9.636572	10.363428	35
9.599536	9.962617	9.636918	10.363081	34
9.599827	9.962562	9.637205	10.362735	33
9.600118	9.962507	9.637610	10.362389	32
9.600409	9.962453	9.637956	10.362044	31
9.600700	9.962398	9.638302	10.361698	30
9.600990	9.962343	9.638647	10.361353	29
9.601280	9.962288	9.638992	10.361007	28
9.601570	9.962233	9.639337	10.360662	27
9.601860	9.962178	9.639682	10.360318	26
9.602149	9.962122	9.640027	10.359973	25
9.602439	9.962067	9.640371	10.359629	24
9.602728	9.962012	9.640716	10.359284	23
9.603017	9.961957	9.641060	10.358940	22
9.603305	9.961902	9.641404	10.358596	21
9.603594	9.961846	9.641747	10.358253	20
9.603882	9.961791	9.642091	10.357909	19
9.604170	9.961735	9.642434	10.357566	18
9.604457	9.961680	9.642777	10.357223	17
9.604745	9.961624	9.643120	10.356980	16
9.605032	9.961569	9.643463	10.356537	15
9.605319	9.961513	9.643806	10.356194	14
9.605606	9.961458	9.644148	10.355852	13
9.605892	9.961402	9.644490	10.355510	12
9.606179	9.961346	9.644832	10.355168	11
9.606465	9.961290	9.645174	10.354826	10
9.606750	9.961235	9.645516	10 354484	9
9.607039	9.961179	9.645857	10.354142	8
9.607322	9.961123	9.646199	10.353801	7
9.607607	9.961067	9.646540	10.353460	6
9.607892	9.961011	9 646881	10.353119	5
9.608176	9.960955	9.647222	10.352778	4
9.608461	9.960899	9.647562	10.352438	3
9.608745	9.960842	9.647903	10.352097	2
9.609029	9.960786	9.648243	10.351757	1
9.609313	9.960730	9.648583	10.351417	0
Co-fine	Sine	*Co-tang.*	Tangent	M

Degree 66.

Degree 24.				
M	Sine	*Co-fine*	Tangent	*Co-tang.*
0	9.609313	9.960730	9.648583	10.351417
1	9.609597	9.960674	9.648923	10.351077
2	9.609880	9.960617	9.649263	10.350737
3	9.610163	9.960561	9.649602	10.350398
4	9.610446	9.960505	9.649942	10.350058
5	9.610729	9.960448	9.650281	10.349719
6	9.611012	9.960392	9.650620	10.349380
7	9.611294	9.960335	9.650959	10.349041
8	9.611576	9.960279	9.651297	10.348703
9	9.611858	9.960222	9.651636	10.348364
10	9.612140	9.960165	9.651974	10.348026
11	9.612421	9.960109	9.652312	10.347688
12	9.612702	9.960052	9.652650	10.347350
13	9.612983	9.959995	9.652988	10.347012
14	9.613264	9.959938	9.653326	10.346674
15	9.613545	9.959881	9.653663	10.346337
16	9.613825	9.959824	9.654000	10.345999
17	9.614105	9.959768	9.654337	10.345662
18	9.614385	9.959710	9.654674	10.345325
19	9.614665	9.959653	9.655011	10.344989
20	9.614944	9.959596	9.655348	10.344652
21	9.615223	9.959539	9.655684	10.344316
22	9.615502	9.959482	9.656020	10.343980
23	9.615781	9.959425	9.656356	10.343643
24	9.616060	9.959367	9.656692	10.343308
25	9.616338	9.959310	9.657028	10.342972
26	9.616616	9.959253	9.657363	10.342636
27	9.616894	9.959195	9.657699	10.342301
28	9.617172	9.959138	9.658034	10.341966
29	9.617450	9.959080	9.658369	10.341531
30	9.617727	9.959023	9.658704	10.341296
31	9.618004	9.958965	9.659039	10.340926
32	9.618281	9.958908	9.659373	10.340627
33	9.618558	9.958850	9.659708	10.340292
34	9.618834	9.958792	9.660042	10.339958
35	9.619110	9.958734	9.660376	10.339624
36	9.619386	9.958677	9.660710	10.339290
37	9.619662	9.958619	9.661043	10.338957
38	9.619938	9.958561	9.661377	10.338623
39	9.620213	9.958503	9.661710	10.338290
40	9.620488	9.958445	9.662043	10.337956
41	9.620763	9.958387	9.662376	10.337623
42	9.621038	9.958329	9.662709	10.337291
43	9.621313	9.958271	9.663042	10.336958
44	9.621587	9.958212	9.663374	10.336625
45	9.621861	9.958154	9.663707	10.336293
46	9.622135	9.958096	9.664039	10.335961
47	9.622409	9.958038	9.664371	10.335629
48	9.622682	9.957979	9.664703	10.335297
49	9.622956	9.957921	9.665035	10.334965
50	9.623229	9.957862	9.665366	10.334634
51	9.623502	9.957804	9.665697	10.334302
52	9.623776	9.957745	9.666029	10.333971
53	9.624047	9.957687	9.666360	10.333640
54	9.624319	9.957628	9.666691	10.333309
55	9.624591	9.957570	9.667021	10.332979
56	9.624863	9.957511	9.667352	10.332648
57	9.625134	9.957452	9.667682	10.332318
58	9.625406	9.957393	9.668012	10.331987
59	9.625677	9.957334	9.668343	10.331657
60	9.625948	9.957276	9.668672	10.331327
	Co-fine	Sine	*Co-tang.*	Tangent

Degree 65.

Degree 25.				
Sine	*Co-fine*	Tangent	*Co-tang.*	
9.625948	9.957276	9.668672	10.331327	60
9.626219	9.957217	9.669002	10.330998	59
9.626490	9.957158	9.669332	10.330668	58
9.626760	9.957099	9.669661	10.330339	57
9.627030	9.957040	9.669990	10.330009	56
9.627300	9.956981	9.670320	10.329680	55
9.627570	9.956922	9.670649	10.329351	54
9.627840	9.956862	9.670977	10.329022	53
9.628109	9.956803	9.671306	10.328694	52
9.628378	9.956744	9.671634	10.328365	51
9.628647	9.956684	9.671963	10.328037	50
9.628916	9.956625	9.672291	10.327709	49
9.629184	9.956565	9.672619	10.327381	48
9.629453	9.956506	9.672947	10.327053	47
9.629721	9.956446	9.673274	10.326725	46
9.629989	9.956387	9.673603	10.326398	45
9.630257	9.956327	9.673929	10.326070	44
9.630524	9.956267	9.674256	10.325743	43
9.630792	9.956208	9.674584	10.325416	42
9.631059	9.956148	9.674910	10.325089	41
9.631326	9.956088	9.675237	10.324763	40
9.631592	9.956029	9.675564	10.324436	39
9.631859	9.955969	9.675890	10.324110	38
9.632125	9.955909	9.676216	10.323783	37
9.632392	9.955849	9.676543	10.323457	36
9.632657	9.955789	9.676869	10.323131	35
9.632923	9.955739	9.677194	10.322805	34
9.633189	9.955669	9.677520	10.322480	33
9.633454	9.955609	9.677845	10.322154	32
9.633719	9.955548	9.678171	10.321829	31
9.633984	9.955488	9.678496	10.321504	30
9.634249	9.955428	9.678821	10.321179	29
9.634514	9.955367	9.679146	10.320854	28
9.634778	9.955307	9.679471	10.320529	27
9.635042	9.955246	9.679795	10.320205	26
9.635306	9.955186	9.680120	10.319880	25
9.635570	9.955125	9.680444	10.319556	24
9.635833	9.955065	9.680768	10.319232	23
9.636097	9.955004	9.681092	10.318908	22
9.636360	9.954944	9.681416	10.318584	21
9.636623	9.954883	9.681740	10.318260	20
9.636886	9.954823	9.682063	10.317937	19
9.637148	9.954762	9.682386	10.317613	18
9.637411	9.954701	9.682710	10.317290	17
9.637673	9.954640	9.683033	10.316967	16
9.637935	9.954579	9.683356	10.316644	15
9.638197	9.954518	9.683678	10.316321	14
9.638458	9.954457	9.684001	10.315999	13
9.638720	9.954396	9.684324	10.315676	12
9.638981	9.954335	9.684646	10.315354	11
9.639241	9.954274	9.684968	10.315032	10
9.639503	9.954213	9.685290	10.314710	9
9.639764	9.954152	9.685612	10.314388	8
9.640024	9.954090	9.685934	10.314066	7
9.640284	9.954029	9.686255	10.313745	6
9.640544	9.953968	9.686577	10.313423	5
9.640804	9.953906	9.686898	10.313102	4
9.641064	9.953845	9.687219	10.312781	3
9.641323	9.953783	9.687540	10.312460	2
9.641583	9.953722	9.687861	10.312138	1
9.641842	9.953660	9.688182	10.311818	0
Co-fine	Sine	*Co-tang.*	Tangent	M

Degree 64.

Canon Triangulorum Logarithmicus.

Degree 26.

M	Sine	*Co-sine*	Tangent	*Co-tang.*
0	9.641842	9.953660	9.688182	10.311818
1	9.642101	9.953598	9.688502	10.311498
2	9.642360	9.953537	9.688823	10.311177
3	9.642618	9.953475	9.689143	10.310857
4	9.642876	9.953413	9.689463	10.310537
5	9.643135	9.953351	9.689783	10.310217
6	9.643393	9.953290	9.690103	10.309897
7	9.643650	9.953228	9.690423	10.309577
8	9.643908	9.953166	9.690742	10.309258
9	9.644165	9.953104	9.691063	10.308938
10	9.644423	9.953042	9.691381	10.308619
11	9.644680	9.952980	9.691700	10.308300
12	9.644936	9.952917	9.692019	10.307981
13	9.645193	9.952855	9.692338	10.307662
14	9.645449	9.952793	9.692656	10.307343
15	9.645706	9.952731	9.692975	10.307025
16	9.645962	9.952668	9.693293	10.306706
17	9.646218	9.952606	9.693612	10.306388
18	9.646473	9.952544	9.693930	10.306070
19	9.646729	9.952481	9.694248	10.305752
20	9.646984	9.952419	9.694566	10.305434
21	9.647239	9.952356	9.694883	10.305117
22	9.647494	9.952294	9.695201	10.304799
23	9.647749	9.952231	9.695518	10.304482
24	9.648004	9.952168	9.695835	10.304164
25	9.648258	9.952105	9.696153	10.303847
26	9.648512	9.952043	9.696470	10.303530
27	9.648766	9.951980	9.696786	10.303213
28	9.649020	9.951917	9.697103	10.302897
29	9.649274	9.951854	9.697420	10.302580
30	9.649527	9.951791	9.697738	10.302264
31	9.649781	9.951728	9.698052	10.301947
32	9.650034	9.951665	9.698369	10.301631
33	9.650287	9.951602	9.698685	10.301315
34	9.650519	9.951539	9.699001	10.300999
35	9.650798	9.951476	9.699316	10.300684
36	9.651044	9.951412	9.699632	10.300368
37	9.651296	9.951349	9.699947	10.300052
38	9.651548	9.951286	9.700263	10.299737
39	9.651800	9.951122	9.700578	10.299422
40	9.652052	9.951159	9.700893	10.299107
41	9.652303	9.951095	9.701208	10.298792
42	9.652555	9.951032	9.701522	10.298477
43	9.652806	9.950968	9.701837	10.298163
44	9.653057	9.950905	9.702152	10.297848
45	9.653307	9.950841	9.702466	10.297534
46	9.653558	9.950777	9.702780	10.297219
47	9.653808	9.950714	9.703095	10.296905
48	9.654059	9.950650	9.703409	10.296591
49	9.654309	9.950586	9.703722	10.296277
50	9.654558	9.950522	9.704036	10.295964
51	9.654808	9.950458	9.704350	10.295650
52	9.655057	9.950394	9.704663	10.295337
53	9.655307	9.950330	9.704976	10.295023
54	9.655556	9.950266	9.705290	10.294710
55	9.655805	9.950202	9.705603	10.294397
56	9.656053	9.950138	9.705915	10.294084
57	9.656302	9.950074	9.706228	10.293771
58	9.656550	9.950009	9.706541	10.293459
59	9.656799	9.949995	9.706853	10.293146
60	9.656347	9.949881	9.707166	10.292834
	Co-sine	Sine	*Co-tang.*	Tangent

Degree 63.

Degree 27.

Sine	*Co-sine*	Tangent	*Co-tang.*	
9.657047	9.949880	9.707166	10.292834	60
9.657295	9.949816	9.707478	10.292523	59
9.657542	9.949752	9.707790	10.292210	58
9.657790	9.949687	9.708102	10.291897	57
9.658037	9.949623	9.708414	10.291586	56
9.658284	9.949598	9.708726	10.291274	55
9.658531	9.949494	9.709037	10.290962	54
9.658777	9.949429	9.709349	10.290651	53
9.659024	9.949364	9.709660	10.290340	52
9.659271	9.949300	9.709971	10.290029	51
9.659517	9.949235	9.710282	10.289718	50
9.659763	9.949170	9.710593	10.289407	49
9.660009	9.949105	9.710904	10.289096	48
9.660255	9.949040	9.711214	10.288785	47
9.660500	9.948976	9.711525	10.288475	46
9.660746	9.948910	9.711836	10.288164	45
9.660991	9.948845	9.712146	10.287854	44
9.661236	9.948760	9.712456	10.287544	43
9.661481	9.948715	9.712766	10.287234	42
9.661726	9.948650	9.713076	10.286924	41
9.661970	9.948584	9.713386	10.286614	40
9.662214	9.948519	9.713695	10.286305	39
9.662459	9.948453	9.714005	10.285995	38
9.662702	9.948388	9.714314	10.285686	37
9.662947	9.948323	9.714624	10.285376	36
9.663190	9.948257	9.714933	10.285067	35
9.663433	9.948191	9.715241	10.284758	34
9.663677	9.948126	9.715550	10.284449	33
9.663920	9.948060	9.715859	10.284140	32
9.664163	9.947995	9.716168	10.283832	31
9.664406	9.947929	9.716477	10.283523	30
9.664648	9.947863	9.716785	10.283215	29
9.664891	9.947797	9.717093	10.282907	28
9.665133	9.947731	9.717401	10.282598	27
9.665375	9.947665	9.717709	10.282290	26
9.665617	9.947599	9.718017	10.281983	25
9.665858	9.947533	9.718325	10.281675	24
9.666100	9.947467	9.718633	10.281367	23
9.666341	9.947401	9.718940	10.281060	22
9.666583	9.947335	9.719248	10.280752	21
9.666824	9.947269	9.719555	10.280445	20
9.667065	9.947203	9.719862	10.280138	19
9.667305	9.947136	9.720169	10.279831	18
9.667546	9.947070	9.720476	10.279524	17
9.667786	9.947004	9.720783	10.279217	16
9.668026	9.946937	9.721089	10.278911	15
9.668266	9.946871	9.721395	10.278604	14
9.668506	9.946804	9.721702	10.278298	13
9.668746	9.946738	9.722008	10.277991	12
9.668986	9.946671	9.722315	10.277685	11
9.669225	9.946604	9.722621	10.277379	10
9.669464	9.946537	9.722927	10.277073	9
.669703	9.946471	9.723232	10.276768	8
9.669942	9.946404	9.723538	10.276462	7
9.670181	9.946337	9.723843	10.276156	6
9.670419	9.946270	9.724149	10.275851	5
9.670657	9.946203	9.724454	10.275546	4
9.670896	9.946136	9.724759	10.275240	3
9.671134	9.946069	9.725065	10.274935	2
9.671372	9.946002	9.725369	10.274630	1
9.671609	9.945935	9.725674	10.274326	0
Co-sine	Sine	*Co-tang.*	Tangent	M

Degree 62.

Canon Triangulorum Logarithmicus.

M	Sine	*Co-fine*	Tangent	*Co-tang.*
Degree 28.				
0	9.671609	9.945935	9.725674	10.274326
1	9.671847	9.945868	9.725979	10.274021
2	9.672084	9.945800	9.726284	10.273816
3	9.672321	9.945733	9.726588	10.273412
4	9.672558	9.945666	9.726892	10.273107
5	9.672795	9.945598	9.727197	10.272803
6	9.673032	9.945531	9.727501	10.272499
7	9.673268	9.945463	9.727805	10.272195
8	9.673505	9.945396	9.728109	10.271891
9	9.673741	9.945328	9.728412	10.271587
10	9.673977	9.945261	9.728716	10.271284
11	9.674213	9.945193	9.729020	10.270980
12	9.674448	9.945125	9.729323	10.270677
13	9.674684	9.945058	9.729626	10.270374
14	9.674919	9.944990	9.729929	10.270070
15	9.675154	9.944922	9.730232	10.269767
16	9.675389	9.944854	9.730535	10.269464
17	9.675623	9.944786	9.730838	10.269162
18	9.675859	9.944718	9.731141	10.268859
19	9.676094	9.944650	9.731443	10.268559
20	9.676328	9.944582	9.731746	10.268254
21	9.676562	9.944514	9.732048	10.267952
22	9.676796	9.944446	9.732351	10.267649
23	9.677030	9.944377	9.732653	10.267347
24	9.677264	9.944309	9.732955	10.267045
25	9.677497	9.944241	9.733257	10.266743
26	9.677731	9.944172	9.733558	10.266441
27	9.677964	9.944104	9.733860	10.266140
28	9.678197	9.944016	9.734162	10.265838
29	9.678430	9.943967	9.734463	10.265537
30	9.678663	9.943898	9.734764	10.265236
31	9.678895	9.943830	9.735066	10.264934
32	9.679128	9.943761	9.735362	10.264633
33	9.679360	9.943692	9.735668	10.264332
34	9.679592	9.943624	9.735968	10.264031
35	9.689824	9.943555	9.736269	10.263731
36	9.680056	9.943486	9.736570	10.263430
37	9.680288	9.943417	9.736870	10.263130
38	9.680519	9.943348	9.737171	10.262829
39	9.680750	9.943279	9.737471	10.262529
40	9.680982	9.943210	9.737771	10.262229
41	9.681213	9.943141	9.738071	10.261929
42	9.681443	9.943072	9.738371	10.261629
43	9.681674	9.943003	9.738671	10.261329
44	9.681904	9.942933	9.738971	10.261029
45	9.682135	9.942864	9.739271	10.260729
46	9.682365	9.942795	9.739570	10.260430
47	9.682595	9.942725	9.739870	10.260130
48	9.682825	9.942656	9.740169	10.259831
49	9.683055	9.942587	9.740468	10.259532
50	9.683284	9.942517	9.740767	10.259233
51	9.683514	9.942448	9.741066	10.258934
52	9.683743	9.942378	9.741365	10.258635
53	9.683972	9.942308	9.741664	10.258336
54	9.684201	9.942239	9.741962	10.258038
55	9.684430	9.942169	9.742261	10.257739
56	9.684658	9.942099	9.742559	10.257441
57	9.684887	9.942029	9.742858	10.257142
58	9.685115	9.941959	9.743156	10.256844
59	9.685343	9.941889	9.743454	10.256546
60	9.685571	9.941819	9.743751	10.256248
	Co-fine.	Sine	*Co-tang.*	Tangent
Degree 61.				

Sine	*Co-fine*	Tangent	*Co-tang.*	
Degree 29.				
9.685571	9.941819	9.743752	10.256248	60
9.685799	9.941749	9.744050	10.255950	59
9.686027	9.941679	9.744348	10.255652	58
9.686254	9.941609	9.744645	10 255355	57
9.686482	9.941539	9.744943	10.255057	56
9.686709	9.941468	9.745240	10.254760	55
9.686936	9.941398	9.745538	10.254462	54
9.687163	9.941328	9.745835	10.254165	53
9.687389	9.941257	9.746132	10.253868	52
9.687616	9.941187	9.746429	10.253571	51
9.687842	9.941116	9.746726	10.253274	50
9.688069	9.941046	9.747023	10.252977	49
9.688295	9.940975	9.747319	10.252680	48
9.688523	9.940905	9.747616	10.252384	47
9.688747	9.940834	9.747912	10.252087	46
9.688972	9.940763	9.748209	10.251791	45
9.689198	9.940693	9.748505	10.251495	44
9.689421	9.940622	9 748801	10.251199	43
9.689648	9.940551	9.749097	10.250902	42
6.689873	9.940480	9.749393	10.250607	41
9.690098	9.940409	9.749689	10.250311	40
9.690323	9.940338	9.749985	10.250015	39
9.690548	9.940267	9.750281	10.249719	38
9.690772	9.940196	9.750576	10.249424	37
9.690996	9.940125	9.750872	10.249128	36
9.691220	9.940053	9.751167	10.248833	35
9.691444	9.939982	9.751462	10.248538	34
9.691668	9.939911	9.751757	10.248243	33
9.691892	9.939840	9.752052	10.247948	32
9.692115	9.939768	9.752347	10.247653	31
9.692339	9.939697	9.752642	10.247358	30
9.692562	9.939625	9.752937	10.247063	29
9.692785	9.939554	9.753231	10.246769	28
9.693008	9.939482	9.753526	10.246474	27
9.693231	9.939410	9.753820	10.246180	26
9.693453	9.939339	9.754115	10.245885	25
9.693676	9.939267	9.754409	10.245591	24
9.693898	9.939195	9.754703	10.245297	23
9.694120	9.939123	9.754997	10.245003	22
9.694342	9.939051	9.755291	10.244709	21
9.694564	9.938980	9.755584	10.244415	20
9.694786	9.938908	9.755878	10.244122	19
9.695007	9.938835	9.756172	10.243828	18
9.695229	9.938763	9.756465	10.243535	17
9.695450	9.938691	9.756759	10.243241	16
9.695671	9.938619	9 757052	10.242948	15
9.695892	9.938547	9.757345	10.242655	14
9.696113	9.938475	9 757638	10.242362	13
9.696334	9.938402	9.757931	10.242069	12
9.696554	9.938330	9.758224	10.241776	11
9.696774	9.938257	9.758517	10.241483	10
9.696995	9.938185	9.758810	10.241190	9
9.697215	9.938112	9.759102	10.240898	8
9.697435	9.938040	9.759395	10.240605	7
9.697654	9.937967	9.759687	10.240313	6
9.697874	9.937895	9.759979	10.240021	5
9.698093	9.937822	9.760271	10.239728	4
9.698313	9.937749	9.760564	10.239436	3
9.698532	9.937676	9.760856	10.239144	2
9.698751	9.937603	9.761147	10.238852	1
9.698970	9.937531	9.761439	10.238561	0
Co-fine	Sine	*Co-tang.*	Tangent	M
Degree 60.				

Canon Triangulorum Logarithmicus.

Degree 30.

M	Sine	Co-sine	Tangent	Co-tang.
0	9.698970	9.937531	9.761439	10.238561
1	9.699189	9.937458	9.761731	10.238269
2	9.699407	9.937385	9.762023	10.237977
3	9.699626	9.937312	9.762314	10.237686
4	9.699844	9.937238	9.762606	10.237394
5	9.700062	9.937165	9.762897	10.237103
6	9.700280	9.937092	9.763188	10.236812
7	9.700498	9.937019	9.763479	10.236521
8	9.700716	9.936945	9.763770	10.236230
9	9.700933	9.936872	9.764061	10.235939
10	9.701151	9.936799	9.764352	10.235648
11	9.701508	9.936725	9.764642	10.235357
12	9.701585	9.936652	9.764933	10.235067
13	9.701802	9.936578	9.765224	10.234776
14	9.702019	9.936505	9.765514	10.234486
15	9.702236	9.936431	9.765805	10.234195
16	9.702452	9.936357	9.766095	10.233905
17	9.702669	9.936284	9.766385	10.233615
18	9.700885	9.936210	9.766675	10.233325
19	9.703101	9.936136	9.766965	10.233035
20	9.703317	9.936062	9.767255	10.232745
21	9.703533	9.935988	9.767545	10.232455
22	9.703748	9.935914	9.767834	10.232166
23	9.703964	9.935840	9.768124	10.231876
24	9.704179	9.935766	9.768413	10.231587
25	9.704395	9.935692	9.768703	10.231297
26	9.704610	9.935618	9.768992	10.231008
27	9.704825	9.935543	9.769281	10.230719
28	9.705040	9.935469	9.769570	10.230430
29	9.705254	9.935395	9.769859	10.230141
30	9.705469	9.935320	9.770148	10.229852
31	9.705683	9.935246	9.770437	10.229563
32	9.705897	9.935171	9.770726	10.229274
33	9.706112	9.935097	9.771015	10.228985
34	9.706326	9.935022	9.771303	10.228697
35	9.706539	9.934948	9.771592	10.228408
36	9.706753	9.934873	9.771880	10.228120
37	9.706967	9.934798	9.772168	10.227832
38	9.707180	9.934723	9.772456	10.227543
39	9.707393	9.934649	9.772745	10.227255
40	9.707606	9.934574	9.773033	10.226967
41	9.707819	9.934499	9.773321	10.226679
42	9.708032	9.934424	9.773608	10.226391
43	9.708245	9.934349	9.773896	10.226104
44	9.708457	9.934274	9.774184	10.225816
45	9.708670	9.934199	9.774471	10.225529
46	9.708882	9.934123	9.774759	10.225241
47	9.709094	9.934048	9.775046	10.224954
48	9.709306	9.933973	9.775333	10.224666
49	9.709518	9.933897	9.775621	10.224379
50	9.709730	9.933822	9.775908	10.224092
51	9.709941	9.933747	9.776195	10.223805
52	9.710153	9.933671	9.776482	10.223518
53	9.710364	9.933596	9.776768	10.223232
54	9.710575	9.933520	9.777055	10.222945
55	9.710786	9.933444	9.777342	10.222658
56	9.710997	9.933369	9.777628	10.222372
57	9.711208	9.933293	9.777915	10.222085
58	9.711418	9.933217	9.778201	10.221799
59	9.711629	9.933141	9.778487	10.221513
60	9.711839	9.933066	9.778774	10.221226
	Co-sine	Sine	Co-tang.	Tangent

Degree 59.

Degree 31.

Sine	Co-sine	Tangent	Co-tang.	
9.711839	9.933066	9.778774	10.221226	60
9.712049	9.932990	9.779060	10.220940	59
9.712259	9.932914	9.779346	10.220654	58
9.712469	9.932838	9.779632	10.220368	57
9.712679	9.932761	9.779918	10.220082	56
9.712889	9.932685	9.780203	10.219796	55
9.713098	9.932609	9.780489	10.219511	54
9.713308	9.932533	9.780775	10.219225	53
9.713517	9.932457	9.781060	10.218940	52
9.713726	9.932380	9.781346	10.218654	51
9.713935	9.932304	9.781631	10.218369	50
9.714144	9.932227	9.781916	10.218084	49
9.714352	9.932151	9.782202	10.217799	48
9.714561	9.932074	9.782486	10.217514	47
9.714769	9.931998	9.782771	10.217229	46
9.714977	9.931921	9.783056	10.216944	45
9.715180	9.931845	9.783341	10.216659	44
9.715394	9.931768	9.783626	10.216374	43
9.715601	9.931691	9.783910	10.216090	42
9.715809	9.931614	9.784195	10.215805	41
9.716017	9.931537	9.784479	10.215520	40
9.716224	9.931460	9.784764	10.215236	39
9.716431	9.931383	9.785048	10.214952	38
9.716639	9.931306	9.785332	10.214668	37
9.716846	9.931229	9.785616	10.214384	36
9.717053	9.931152	9.785900	10.214099	35
9.717259	9.931075	9.786184	10.213816	34
9.717463	9.930998	9.786468	10.213532	33
9.717672	9.930920	9.786752	10.213248	32
9.717879	9.930843	9.787036	10.212964	31
9.718085	9.930766	9.787319	10.212681	30
9.718291	9.930688	9.787603	10.212397	29
9.718497	9.930611	9.787886	10.212114	28
9.718703	9.930533	9.788170	10.211830	27
9.718909	9.930456	9.788453	10.211547	26
9.719114	9.930378	9.788736	10.211264	25
9.719320	9.930300	9.789019	10.210981	24
9.719525	9.930223	9.789302	10.210698	23
9.719730	9.930145	9.789585	10.210415	22
9.719935	9.930067	9.789868	10.210132	21
9.720140	9.929989	9.790151	10.209849	20
9.720345	9.929911	9.790433	10.209566	19
9.720549	9.929833	9.790716	10.209284	18
9.720754	9.929755	9.790999	10.209001	17
9.720958	9.929677	9.791281	10.208719	16
9.721162	9.929599	9.791563	10.208436	15
9.721360	9.929521	9.791846	10.208154	14
9.721570	9.929442	9.792128	10.207872	13
9.721774	9.929364	9.792410	10.207590	12
9.721978	9.929286	9.792692	10.207308	11
9.722181	9.929207	9.792974	10.207028	10
9.722385	9.929129	9.793256	10.206744	9
9.722588	9.929050	9.793538	10.206462	8
9.722791	9.928972	9.793819	10.206180	7
9.722994	9.928893	9.794101	10.205899	6
9.723197	9.928814	9.794383	10.205617	5
9.723400	9.928736	9.794664	10.205336	4
9.723603	9.928657	9.694945	10.205054	3
9.723805	9.928578	9.795227	10.204773	2
9.724007	9.928499	9.795508	10.204492	1
9.724210	9.928420	9.795789	10.204211	0
Co-sine	Sine	Co-tang.	Tangent	M

Degree 58.

Canon Triangulorum Logarithmicus.

Degree 32.

M	Sine	*Co-sine*	Tangent	*Co-tang.*
0	9.724210	9.928420	9.795789	10.204211
1	9.724412	9.928341	9.796070	10.203930
2	9.724614	9.928262	9.796351	10.203649
3	9.724816	9.928183	9.796632	10.203368
4	9.725017	9.928104	9.796913	10.203087
5	9.725219	9.928025	9.897194	10.202806
6	9.725420	9.927946	9.797474	10.202522
7	9.725622	9.927867	9.797755	10.202245
8	9.725823	9.927787	9.798036	10.201964
9	9.726024	9.927708	9.798316	10.201684
10	9.726225	9.927628	9.798596	10.201404
11	9.726426	9.927549	9.798877	10.201123
12	9.726626	9.927469	9.799157	10.200843
13	9.726827	9.927390	9.799437	10.200563
14	9.727027	9.927310	9.799717	10.200283
15	9.727228	9.927231	9.799997	10.200003
16	9.727428	9.927151	9.800277	10.199723
17	9.727628	9.927071	9.800557	10.199443
18	9.727828	9.926991	9.800836	10.199163
19	9.728027	9.926911	9.801116	10.198884
20	9.728227	9.926831	9.801396	10.198604
21	9.728427	9.926751	9.801675	10.198325
22	9.728626	9.926671	9.801955	10.198045
23	9.728825	9.926591	9.802234	10.197766
24	9.729024	9.926511	9.802513	10.197487
25	9.729223	9.926431	9.802792	10.197207
26	9.729422	9.926351	9.803072	10.196928
27	9.729621	9.926270	9.803351	10.196649
28	9.729820	9.926190	9.803630	10.196370
29	9.720018	9.926110	9.803908	10.196091
30	9.720216	9.926029	9.804187	10.195813
31	9.730415	9.925949	9.804466	10.195534
32	9.730613	9.925868	9.804745	10.195255
33	9.730811	9.925787	9.805023	10.194977
34	9.731009	9.925707	9.805302	10.194698
35	9.731206	9.925626	9.805580	10.194420
36	9.731404	9.925545	9.805859	10.194141
37	9.731601	9.925464	9.806137	10.193863
38	9.731799	9.925384	9 806415	10.193585
39	9.731996	9.925303	9.806693	10.193309
40	9.732193	9.925222	9.806971	10.193028
41	9.732390	9.925141	9.807249	10.192751
42	9.732587	9.925060	9.807527	10.192433
43	9.732784	9.924978	9.807805	10.192195
44	9.732980	9.924867	9 808083	10.191917
45	9.733177	9.924816	9.808361	10.191639
46	9.733373	9.924735	9.808638	10.191362
47	9.733569	9.924653	9.808916	10.191084
48	9.733765	9.924572	9.809193	10.190807
49	9.733961	9.924491	9.809471	10.190529
50	9.734157	9.924409	9.809748	10.190252
51	9.734353	9.924328	9.810025	10.189975
52	9.734548	9.924246	9.810302	10.189697
53	9.734744	9.924164	9.810580	10.189420
54	9.734939	9.924083	9.810857	10.189143
55	9.735134	9.924001	9 811134	10.188866
56	9.735330	9.923919	9.811410	10.188589
57	9.735525	9.923837	9.811687	10.188313
58	9.735719	9.923755	9.811964	10.188036
59	9.735914	9.923673	9.812241	10.187759
60	9.736109	9.923591	9.812517	10.187483
	Co-sine	Sine	*Co-tang.*	Tangent

Degree 57.

Degree 33.

Sine	*Co-sine*	Tangent	*Co-tang.*	
9.736109	9.923591	9.812517	10.187483	60
9.736309	9.923509	9.812794	10.187206	59
9.736497	9.923427	9.813070	10.186930	58
9.736692	9.923345	9.813347	10.186653	57
9.736886	9.923263	9.813623	10.186377	56
9.737080	9.923180	9.813899	10.186101	55
9.737274	9.923098	9.814175	10.185824	54
9.737467	9.923016	9.814452	10.185548	53
9.737661	9.922933	9.814728	10.185272	52
9.737854	9.922851	9.815004	10.184996	51
9.738048	9.922768	9.815279	10.184720	50
9.738241	9.922686	9.815555	10.184445	49
9.738434	9.922603	9.815831	10.184169	48
9.738627	9.922520	9.816107	10.183893	47
9.738820	9.922438	9.816382	10.183617	46
9.739013	9.922355	9.816658	10.183342	45
9.739205	9.922272	9.816933	10.183066	44
9.739398	9.922189	9.817209	10.182791	43
9.739590	9.922106	9.817484	10.182516	42
9.739783	9.922023	9.817759	10.182240	41
9.739975	9.921940	9.818035	10.181965	40
9.740167	9.921857	9.818310	10.181690	39
9.740359	9.921774	9.818585	10.181415	38
9.740550	9.921691	9.818860	10.181140	37
9.740742	9.921607	9.819135	10.180865	36
9.740934	9.921524	9.819410	10.180590	35
9.741125	9.921441	9.819684	10.180315	34
9.741316	9.921357	9.819959	10.180041	33
9.741507	9.921274	9.820234	10.179766	32
9.741698	9.921190	9.820508	10.179492	31
9.741889	9 921107	9.820783	10.179217	30
9.742080	9.921023	9.821057	10.178943	29
9.742271	9.920939	9.821332	10.178668	28
9.742461	9.920855	9.821606	10.178394	27
9.742652	9.920772	9.821880	10.178120	26
9.742842	9.920688	9.822154	10.177846	25
9.743032	9.920604	9.822429	10.177571	24
9.743223	9.920520	9.822703	10.177297	23
9.743412	9.920436	9.822077	10.177023	22
9.743602	9.920352	9.823250	10.176739	21
9.743792	9.920268	9.823524	10.176476	20
9.743982	9.920184	9.823798	10.176202	19
9.744171	9.920099	9.824072	10.175928	18
9.744361	9.920015	9.824345	10.175655	17
9.744550	9.919931	9.824619	10.175381	16
9.744739	9.919846	9.824892	10.175108	15
9.744928	9.919762	9.825166	10.174834	14
9.745117	9.919677	9.825439	10.174560	13
9.745306	9.919593	9.825713	10.174287	12
9.745494	9.919508	9.825986	10.174014	11
9.745683	9.919424	9.826259	10.173741	10
9.745871	9.919339	9.826532	10.173498	9
9.746059	9.919254	9.826805	10.173195	8
9.746248	9.919169	9.827078	10.172922	7
9.746436	9.919084	9.827351	10.172649	6
9.746624	9.918999	9.827624	10.172376	5
9.746811	9.918915	9.827897	10.172103	4
9.746999	9.918830	9.828170	10.171830	3
9.747187	9.918744	9.828442	10.171558	2
9.747374	9.918659	9.828715	10.171285	1
9.747562	9.918574	9.828987	10.171012	0
Co-sine	Sine	*Co-tang.*	Tangent	M

Degree 56.

Canon Triangulorum Logarithmicus.

Degree 34.

M	Sine	*Co-sine*	Tangent	*Co-tang.*
0	9.747562	9.918574	9.828987	10.171012
1	9.747749	9.918489	9.829260	10.170740
2	9.747936	9.918404	9.829532	10.170468
3	9.748123	9.918318	9.829805	10.170195
4	9.748310	9.918233	9.830077	10.169923
5	9.748497	9.918147	9.830349	10.169651
6	9.748683	9.918062	9.830621	10.169379
7	9.748870	9.917976	9.830893	10.166106
8	9.749056	9.917891	9.831165	10.168834
9	9.749242	9.917805	9.831437	10.168563
10	9.749429	9.917719	9.831709	10.168291
11	9.749615	9.917634	9.831981	10.168019
12	9.749801	9.917548	9.832253	10.167747
13	9.749986	9.917462	9.832525	10.167475
14	9.750172	9.917376	9.832796	10.167204
15	9.750358	9.917290	9.833068	10.166932
16	9.750543	9.917204	9.833339	10.166660
17	9.750729	9.917118	9.833611	10.166389
18	9.750914	9.917032	9.833882	10.166118
19	9.751099	9.916945	9.834154	10.165846
20	9.751284	9.916859	9.834425	10.165575
21	9.751469	9.916773	9.834696	10.165304
22	9.751654	9.916686	9.834967	10.165033
23	9.751838	9.916600	9.835238	10.164762
24	9.752023	9.916514	9.835509	10.164491
25	9.752207	9.916427	9.835780	10.164220
26	9.752392	9.916340	9.836051	10.163949
27	9.752576	9.916254	9.836322	10.163678
28	9.752760	9.916167	9.836593	10.163407
29	9.752944	9.916080	9.836864	10.163136
30	9.753128	9.915994	9.837134	10.162866
31	9.753312	9.915907	9.837405	10.162595
32	9.753495	9.915820	9.837675	10.162325
33	9.753679	9.915733	9.837946	10.162054
34	9.753862	9.915646	9.838216	10.161784
35	9.754046	9.915559	9.838487	10.161513
36	9.754229	9.915472	9.838757	10.161243
37	9.754412	9.915385	9.839027	10.160973
38	9.754595	9.915297	9.839297	10.160702
39	9.754778	9.915210	9.839568	10.160432
40	9.754960	9.915123	9.839838	10.160162
41	9.755143	9.915035	9.840108	10.159892
42	9.755325	9.914948	9.840378	10.159622
43	9.755508	9.914860	9.840647	10.159352
44	9.755690	9.914773	9.840917	10.159083
45	9.755872	9.914685	9.841187	10.158813
46	9.756054	9.914597	9.841457	10.158543
47	9.756236	9.914510	9.841726	10.158273
48	9.756418	9.914422	9.841996	10.158004
49	9.756600	9.914334	9.842266	10.157734
50	9.756781	9.914246	9.842535	10.157465
51	9.756963	9.914158	9.842804	10.157195
52	9.757144	9.914070	9.843074	10.156926
53	9.757326	9.913982	9.843343	10.156657
54	9.757507	9.913894	9.843612	10.156387
55	9.757688	9.913806	9.843882	10.156118
56	9.757869	9.913718	9.844151	10.155849
57	9.758049	9.913630	9.844420	10.155580
58	9.758230	9.913541	9.844689	10.155311
59	9.758411	9.913453	9.844958	10.155042
60	9.758591	9.913364	9.845227	10.154774
	Co-sine.	Sine	*Co-tang.*	Tangent

Degree 55.

Degree 35.

Sine	*Co-sine*	Tangent	*Co-tang.*	
9.758591	9.913364	9.845227	10.154774	60
9.758772	9.913276	9.845496	10.154504	59
9.758952	9.913187	9.845764	10.154235	58
9.759132	9.913099	9.846033	10.153967	57
9.759312	9.913010	9.846302	10.153698	56
9.759492	9.912921	9.846570	10.153429	55
9.759672	9.912835	9.846839	10.153161	54
9.759851	9.912744	9.847107	10.153892	53
9.760031	9.912655	9.847376	10.152624	52
9.760210	9.912566	9.847644	10.152356	51
9.760390	9.912477	9.947913	10.152087	50
9.760569	9.912388	9.848181	10.151819	49
9.760748	9.912299	9.848449	10.151551	48
9.760927	9.912210	9.848717	10.151283	47
9.761106	9.912121	9.848985	10.151015	46
9.761285	9.912031	9.849254	10.150746	45
9.761464	9.911942	9.849522	10.150478	44
9.761642	9.911853	9.849789	10.150214	43
9.761821	9.911763	9.850057	10.149943	42
9.761999	9.911674	9.850325	10.149675	41
9.762177	9.911584	9.850593	10.149407	40
9.762356	9.911495	9.850861	10.149139	39
9.762534	9.911405	9.851128	10.148872	38
9.762712	9.911315	9.851396	10.148604	37
9.762889	9.911226	9.851664	10.148336	36
9.763067	9.911136	9.851931	10.148069	35
9.763245	9.911046	9.852199	10.147801	34
9.763422	9.910956	9.852466	10.147534	33
9.763599	9.910866	9.852731	10.147267	32
9.763777	9.910776	9.853001	10.146999	31
9.763954	9.010686	9.853268	10.146732	30
9.764131	9.910596	9.853532	10.146465	29
9.764308	9.910506	9.853802	10.146198	28
9.764485	9.910415	9.854069	10.145930	27
9.764662	9.910325	9.854336	10.145664	26
9.764838	9.910235	9.854603	10.145397	25
9.765015	9.910144	9.854870	10.145130	24
9.765191	9.910054	9.855137	10.144863	23
9.765367	9.909963	9.855404	10.144596	22
9.765544	9.909873	9.855671	10.144329	21
9.765720	9.909782	9.855937	10.144063	20
9.765896	9.909691	9.856204	10.143796	19
9.766071	9.909601	9.856471	10.143529	18
9.766247	9.909510	9.856737	10.143263	17
9.766423	9.909419	9.857004	10.142996	16
9.766598	9.909328	9.857270	10.142730	15
9.766774	9.909237	9.857537	10.142463	14
9.766949	9.909146	9.857803	10.142197	13
9.767124	9.909055	9.858069	10.141931	12
9.767299	9.908964	9.858336	10.141664	11
9.767474	9.908873	9.858602	10.141398	10
9.767649	9.908781	9.858868	10.141132	9
9.767824	9.908690	9.859134	10.140866	8
9.767997	9.908599	9.859400	10.140600	7
9.768173	9.908507	9.859666	10.140334	6
9.768348	9.908416	9.859932	10.140068	5
9.768522	9.908324	9.860198	10.139802	4
9.768696	9.908233	9.860464	10.139536	3
9.768871	9.908141	9.860730	10.139270	2
9.769045	9.908049	9.860995	10.139005	1
9.769219	9.907958	9.861261	10.138739	0
Co-sine	Sine	*Co-tang.*	Tangent	M

Degree 54.

Canon Triangulorum Logarithmicus.

Degree 36.

M	Sine	*Co-fine*	Tangent	*Co-tang.*
0	9.769219	9.907958	9.861261	10.138739
1	9.769392	9.907866	9.861527	10.138473
2	9.769566	9.907774	9.861792	10.138208
3	9.769740	9.907682	9.862058	10.137942
4	9.769913	9.907590	9.862323	10.137677
5	9.770087	9.907498	9.862589	10.137411
6	9.770260	9.907406	9.862854	10.137146
7	9.770433	9.907314	9.863119	10.136880
8	9.770606	9.907221	9.863385	10.136615
9	9.770779	9.907129	9.863650	10.136350
10	9.770952	9.907037	9.863915	10.136085
11	9.771125	9.906945	9.864180	10.135820
12	9.771298	9.906852	9.864445	10.135554
13	9.771470	9.906760	9.864710	10.135289
14	9.771643	9.906667	9.864975	10.135024
15	9.771815	9.906574	9.865240	10.134759
16	9.771987	9.906482	9.865505	10.134495
17	9.772159	9.906389	9.865770	10.134230
18	9.772331	9.906296	9.866035	10.133965
19	9.772503	9.906203	9.866300	10.133700
20	9.772675	9.906111	9.866564	10.133436
21	9.772847	9.906018	6.8668829	10.133171
22	9.773018	9.905925	9.867094	10.132906
23	9.773190	9.905832	9.867358	10.132642
24	9.773361	9.905738	9.867623	10.132377
25	9.773533	9.905645	9.867887	10.132113
26	9.773704	9.905552	9.868152	10.131848
27	9.773875	9.905459	9.868416	10.131584
28	9.774046	9.905365	9.868680	10.131320
29	9.774217	9.905272	9.868945	10.131055
30	9.774388	9.905179	9.869209	10.130791
31	9.774558	9.905085	9.864773	10.130527
32	9.774729	9.904992	9.867337	10.130263
33	9.774899	9.904898	9.870001	10.129999
34	9.775070	9.904804	9.870265	10.129735
35	9.775240	9.904711	9.870529	10.129471
36	9.775410	9.904617	9.870793	10.129207
37	9.775580	9.904523	9.871057	10.128943
38	9.775750	9.904429	9.871321	10.128679
39	9.775920	9.904335	9.871585	10.128415
40	9.776090	9.904241	9.871849	10.128151
41	9.776259	9 904147	9.872112	10.127888
42	9.776429	9.904053	9.872376	10.127624
43	9.776598	9.903959	9.872640	10.127360
44	9.776768	9.903864	9.872903	10.127097
45	9.776937	9.903770	9 873167	10.126833
46	9.777106	9.903676	9.873430	10.126570
47	9.777275	9.903581	9 873694	10.126306
48	9.777444	9.903486	9.873957	10.126043
49	9.777613	9.903392	9.874220	10.125780
50	9.777781	9.903298	9.874484	10.125516
51	9.777950	9.903203	9.874747	10.125253
52	9.778119	9.903108	9.875010	10.124990
53	9.778287	9.903013	9.875273	10.124727
54	9.778455	9.902919	9.875536	10.124464
55	9.778623	9.902824	9.875799	10.124201
56	9.778792	9.902729	9.876063	10.123937
57	9.778960	9.902634	9.876326	10.123674
58	9.779129	9.902539	9.876589	10.223411
59	9.779295	9.902444	9.876851	10.123149
60	9.779463	9.902349	9.877114	10.122886
	Co-fine	Sine	*Co-tang.*	Tangent

Degree 53.

Degree 37.

Sine	*Co-tang.*	Tangent	*Co-fine*	
9.779463	9.902349	9.877114	10.122885	60
9.779631	9.902253	9.877377	10.122623	59
9.779798	9.902158	9.877640	10.122360	58
9.779965	9.902063	9.877903	10.122097	57
9.780133	9.901967	9.878165	10.121834	56
9.780300	9 901872	9.878428	10.121572	55
9.780467	9.901776	9.878691	10.121309	54
9.780634	9.901681	9.878953	10 121047	53
9.780801	9.901585	9.879216	10.120784	52
9.780968	9.901488	9.879478	10.120522	51
9.781134	9.901391	9.879741	10.120259	50
9.781301	9.901298	9.880003	10.119997	49
9.781467	9.901202	9.880265	10.119734	48
9.781634	9.901106	9.880528	10.119472	47
9.781800	9.901010	9.880790	10.119210	46
9.781966	9.900914	9.881052	10.118948	45
9.782132	9.900828	9.881314	10.118686	44
9.782298	9.900722	9.881576	10.118424	43
9.782464	9.900626	9.881839	10.118161	42
9 782690	9.900529	9.882101	10.117899	41
9.782796	9.900433	6.882363	10.117637	40
9.782961	9.900337	9.882625	10.117375	39
9.783127	9.900240	9.882886	10.117114	38
9.783292	9.900144	9.883148	10.116852	37
9.783457	9.900047	9.883410	10.116590	36
9.783623	9.899951	9.883672	10.116328	35
9.783788	9.899854	9.883934	10.116066	34
9.783953	9,899757	9.884195	10.115805	33
9.784118	9.899660	9.884457	10.115543	32
9.784282	9.899563	9.884719	10.115281	31
9.784447	9.899467	9.884980	10.115020	30
9.784616	9.899370	9.885242	10.114758	29
9.784776	9.899273	9.885503	10.114497	28
9.784941	9.899175	9.885765	10.114235	27
9.785105	9.899078	9.886026	10.113974	26
9.785269	9.898981	9.886288	10.113712	25
9.785433	9.898884	9.886549	10.113451	24
9.785591	9.898787	9.886810	10.113190	23
9.785761	9.898689	9.887072	10.112928	22
9.785925	9.898592	9.887333	10.112667	21
9 786088	9.898494	9.887564	10.112406	20
9 786252	9.898397	9.8887855	10.112145	19
9.786416	9.898299	9.888116	10.111884	18
9.786579	9.898201	9.888377	10.111623	17
9.786742	9.898104	9.888638	10.111362	16
9.786909	9.898006	9.888899	10.111101	15
9.787069	9.897908	9.889160	10.110840	14
9.787232	9.897810	9.889421	10.110579	13
9.787395	9.897112	9.889682	10.110318	12
9.787557	9.897614	9.889943	10.110057	11
9.787720	9.897516	9.890204	10.109796	10
9.787883	9.897418	9.890465	10.109535	9
9.788045	9.897320	9.890725	10.109275	8
9.788208	9.897222	9.890986	10.109014	7
9.788370	9.897123	9.891247	10.108753	6
9.788532	9.397025	9.891507	10.108493	5
9.788694	9.896926	9.891768	10.108232	4
9.788856	9.896828	9.892028	10.107972	3
9.789018	9.896729	9.892289	10.107711	2
9.789180	9.896631	9.892549	10.107451	1
9.789342	9.896532	9.892810	10.107190	0
Co-fine	Sine	*Co-tang.*	Tangent	M

Degree 52.

Canon Triangulorum Logarithmicus.

Degree 38.

M	Sine	Co-sine	Tangent	Co-tang.
0	9.789342	9.896532	9.892810	10.107190
1	9.789504	9.896433	9.893070	10.106930
2	9.789665	9.896335	9.893330	10.106669
3	9.789827	9.896236	9.893591	10.106409
4	9.789988	9.896137	9.893851	10.106149
5	9.790149	9.896038	9.894111	10.105889
6	9.790310	9.895939	9.894371	10.105628
7	9.790471	9.895840	9.894632	10.105368
8	9.790632	9.895741	9.894892	10.105108
9	9.790793	9.895641	9.895152	10.104848
10	9.790954	9.895542	9.895412	10.104588
11	9.791115	9.895443	9.895672	10.104328
12	9.791275	9.895343	9.895932	10.104068
13	9.791436	9.895244	9.896192	10.103808
14	9.791596	9.895144	9.896452	10.103548
15	9.791756	9.895045	9.896712	10.103288
16	9.791917	9.894945	9.896971	10.103028
17	9.792077	9.894846	9.897231	10.102769
18	9.792237	9.894746	9.897491	10.102509
19	9.792397	9.894646	9.897751	10.102249
20	9.792557	9.894546	9.898010	10.101990
21	9.792716	9.894445	9.898270	10.101730
22	9.792876	9.894346	9.898520	10.101470
23	9.793035	9.894246	9.898789	10.101211
24	9.793195	9.894146	9.899049	10.100951
25	9.793354	9.894046	9.899308	10.100692
26	9.793513	9.893946	9.899568	10.100432
27	9.793673	9.893845	9.899827	10.100173
28	9.793832	9.893745	9.900086	10.099913
29	9.793991	9.893645	9.900346	10.099654
30	9.794149	9.893544	9.900605	10.099395
31	9.794308	9.893444	9.900864	10.099135
32	9.794467	9.893343	9.901124	10.098876
33	9.794626	9.893243	9.901383	10.098617
34	9.794784	9.893142	9.901642	10.098358
35	9.794942	9.893041	9.901901	10.098099
36	9.795101	9.892940	9.902160	10.097839
37	9.795259	9.892839	9.902419	10.097580
38	9.795417	9.892738	9.902678	10.097321
39	9.795575	9.892637	9.902937	10.097062
40	9.795733	9.892536	9.903196	10.096803
41	9.795891	9.892435	9.903455	10.096544
42	9.796049	9.892334	9.903714	10.096285
43	9.796206	9.892233	9.903973	10.096027
44	9.796364	9.892132	9.904232	10.095768
45	9.796521	9.892030	9.904491	10.095509
46	9.796678	9.891929	9.904750	10.095250
47	9.796836	9.891827	9.905008	10.094991
48	9.796993	9.891726	9.905267	10.094733
49	9.797150	9.891624	9.905526	10.094474
50	9.797307	9.891522	9.905784	10.094215
51	9.797464	9.891421	9.906043	10.093957
52	9.797621	9.891319	9.906302	10.093698
53	9.797777	9.891217	9.906560	10.093440
54	9.797934	9.891115	9.906819	10.093181
55	9.798091	9.891013	9.907077	10.092923
56	9.798247	9.890911	9.907336	10.092664
57	9.798403	9.890809	9.907594	10.092406
58	9.798560	9.890707	9.907852	10.092147
59	9.798716	9.890605	9.908111	10.091889
60	9.798872	9.890503	9.908369	10.091631
	Co-sine	Sine	Co-tang.	Tangent

Degree 51.

Degree 39.

Sine	Co-sine	Tangent	Co-tang.	
9.798872	9.890503	9.908369	10.091631	60
9.799028	9.890400	9.908627	10.091373	59
9.799184	9.890298	9.908886	10.091114	58
9.799339	9.890195	9.909144	10.090856	57
9.799495	9.890093	9.909402	10.090598	56
9.799651	9.889990	9.909660	10.090340	55
9.799806	9.889888	9.909918	10.090081	54
9.799961	9.889785	9.910176	10.089823	53
9.800117	9.889682	9.910435	10.089565	52
9.800272	9.889579	9.910693	10.089307	51
9.800427	9.889476	9.910951	10.089049	50
9.800582	9.889374	9.911209	10.088791	49
9.800737	9.889271	9.911467	10.088533	48
9.800892	9.889167	9.911724	10.088275	47
9.801047	9.889064	9.911982	10.088017	46
9.801201	9.888961	9.912240	10.087760	45
9.801356	9.888858	9.912498	10.087502	44
9.801510	9.888755	9.912756	10.087244	43
9.801665	9.888651	9.913014	10.086986	42
9.801819	9.888548	9.913271	10.086729	41
9.801973	9.888444	9.913529	10.086471	40
9.802127	9.888341	9.913787	10.086213	39
9.802282	9.888237	9.914044	10.085956	38
9.802435	9.888133	9.914302	10.085698	37
9.802589	9.888030	9.914560	10.085440	36
9.802743	9.887926	9.914817	10.085183	35
9.802897	9.887822	9.915075	10.084925	34
9.803050	9.887718	9.915332	10.084668	33
9.803204	9.887614	9.915590	10.084410	32
9.803357	9.887510	9.915847	10.084153	31
9.803510	9.887406	9.916104	10.083895	30
9.803664	9.887302	9.916362	10.083638	29
9.803817	9.887198	9.916619	10.083381	28
9.803970	9.887093	9.916876	10.083123	27
9.804123	9.886989	9.917134	10.082866	26
9.804276	9.886884	9.917391	10.082609	25
9.804428	9.886780	9.917648	10.082352	24
9.804581	9.886675	9.917905	10.082094	23
9.804734	9.886571	9.918162	10.081837	22
9.804886	9.886466	9.918420	10.081580	21
9.805038	9.886361	9.918677	10.081323	20
9.805191	9.886257	9.918934	10.081066	19
9.805343	9.886152	9.919191	10.080809	18
9.805495	9.886047	9.919448	10.080552	17
9.805647	9.885942	9.919705	10.080295	16
9.805799	9.885837	9.919962	10.080038	15
9.805951	9.885732	9.920219	10.079781	14
9.806103	9.885627	9.920476	10.079524	13
9.806254	9.885521	9.920733	10.079267	12
9.806406	9.885416	9.920990	10.079010	11
9.806557	9.885311	9.921247	10.078753	10
9.806709	9.885205	9.921503	10.078496	9
9.806860	9.885100	9.921760	10.078240	8
9.807011	9.884994	9.922017	10.077983	7
9.807162	9.884889	9.922274	10.077726	6
9.807314	9.884783	9.922530	10.077469	5
9.807464	9.884677	9.922787	10.077213	4
9.807615	9.884572	9.923044	10.076956	3
9.807766	9.884466	9.923302	10.076699	2
9.807917	9.884360	9.923557	10.076443	1
9.808067	9.884254	9.923813	10.076186	0
Co-sine	Sine	Co-tang.	Tangent	M

Degree 50.

Canon Triangulorum Logarithmicus.

Degree 40.

M	Sine	*Co-fine*	Tangent	*Co-tang.*
0	9.808067	9.884254	9.923813	10.076186
1	9.808218	9.884148	9.924070	10.075930
2	9.808368	9.884042	9.924327	10.075673
3	9.808515	9.883936	9.924583	10.075417
4	9.808669	9.883829	9.924839	10.075160
5	9.808819	9.883723	9.925096	10.074904
6	9.808969	9.883617	9.925352	10.074647
7	9.809119	9.883510	9.925609	10.074391
8	9.809269	9.883404	9.925865	10.074135
9	9.809419	9.883297	9.926121	10.073878
10	9.809569	9.883191	9.926378	10.073622
11	9.809718	9.883084	9.926634	10.073366
12	9.809868	9.882977	9.926890	10.073110
13	9.810017	9.882871	9.927147	10.072853
14	9.810166	9.882764	9.927403	10.072597
15	9.810316	9.882657	9.927659	10.072341
16	9.810465	9.882550	9.927915	10.072085
17	9.810614	9.882443	9.928171	10.071829
18	9.810763	9.882336	9.928427	10.071573
19	9.810912	9.882228	9.928683	10.071317
20	9.811061	9.882121	9.928940	10.071060
21	9.811210	9.882014	9.929196	10.070804
22	9.811358	9.881907	9.929452	10.070540
23	9.811506	9.881799	9.929708	10.070292
24	9.811655	9.881692	9.929964	10.070036
25	9.811804	9.881584	9.930219	10.069781
26	9.811952	9.881477	9.930475	10.069525
27	9.812100	9.881369	9.930731	10.069269
28	9.812248	9.881261	9.930987	10.069013
29	9.812396	9.881153	9.931243	10.068757
30	9.812544	9.881045	9.931499	10.068501
31	9.812692	9.880937	9.931755	10.068245
32	9.812840	9.880829	9.932010	10.067989
33	9.812988	9.880721	9.932266	10.067734
34	9.813135	9.880613	9.932522	10.067478
35	9.813283	9.880505	9.932778	10.067222
36	9.813430	9.880397	9.933033	10.066967
37	9.813578	9.880289	9.933289	10.066711
38	9.813725	9.880180	9.933545	10.066455
39	9.813872	9.880072	9.933800	10.066200
40	9.814019	9.879963	9.934056	10.065944
41	9.814166	9.879855	9.934311	10.065688
42	9.814313	9.879746	9.934561	10.065433
43	9.814460	9.879637	9.934822	10.065177
44	9.814607	9.879529	9.935078	10.064922
45	9.814753	9.879420	9.935333	10.064666
46	9.814900	9.879311	9.935589	10.064411
47	9.815046	9.879202	9.935844	10.064156
48	9.815193	9.879093	9.936100	10.063900
49	9.815339	9.878984	9.936355	10.063645
50	9.815485	9.878875	9.936610	10.063389
51	9.815631	9.878766	9.936866	10.063134
52	9.815777	9.878656	9.937121	10.062879
53	9.815923	9.878547	9.937376	10.062923
54	9.816069	9.878438	9.937632	10.062368
55	9.816215	9.878328	9.937887	10.062113
56	9.816361	9.878219	9.938142	10.061858
57	9.816506	9.878109	9.938397	10.061602
58	9.816652	9.877999	9.938653	10.061347
59	9.816797	9.877890	9.938908	10.061092
60	9.816943	9.877780	9.939163	10.060837
	Co-fine	Sine	*Co-tang.*	Tangent

Degree 49.

Degree 41.

Sine	*Co-fine*	Tangent	*Co-tang.*	
9.816943	9.877780	9.939163	10.060837	60
9.817088	9.877670	9.939418	10.060582	59
9.817233	9.877560	9.939673	10.060327	58
9.817378	9.877450	9.939928	10.060072	57
9.817524	9.877340	9.940183	10.059816	56
9.817668	9.877230	9.940438	10.059562	55
9.817813	9.877120	9.940693	10.059307	54
9.817958	9.877009	9.940948	10.059052	53
9.818103	9.876899	9.941203	10.058797	52
9.818247	9.876789	9.941458	10.058542	51
9.818392	9.876678	9.941713	10.058287	50
9.818536	9.876568	9.941968	10.058032	49
9.818681	9.876457	9.942223	10.057777	48
9.818825	9.876347	9.942478	10.057522	47
9.818969	9.876236	9.942733	10.057267	46
9.819113	9.876125	9.942988	10.057012	45
9.819257	9.876014	9.943243	10.056757	44
9.819401	9.875904	9.943498	10.056502	43
9.819545	9.875793	9.943752	10.056248	42
9.819689	9.875682	9.944007	10.055993	41
9.819832	9.875571	9.944262	10.055738	40
9.819976	9.875459	9.944517	10.055483	39
9.820119	9.875348	9.944771	10.055229	38
9.820263	9.875237	9.945026	10.054974	37
9.820406	9.875125	9.945281	10.054719	36
9.820549	9.875014	9.945535	10.054464	35
9.820693	9.874903	9.945790	10.054210	34
9.820836	9.874791	9.946045	10.053955	33
9.820979	9.874679	9.946299	10.053701	32
9.821122	9.874568	9.946554	10.053446	31
9.821267	9.874456	9.946808	10.053192	30
9.821407	9.874344	9.947063	10.052937	29
9.821550	9.874232	9.947317	10.052682	28
9.821692	9.874120	9.947572	10.052428	27
9.821835	9.874008	9.947826	10.052173	26
9.821977	9.873896	9.948081	10.051919	25
9.822120	9.873784	9.948335	10.051664	24
9.822262	9.873672	9.948590	10.051410	23
9.822404	9.873560	9.948844	10.041156	22
9.822546	9.873447	9.949099	10.040901	21
9.822688	9.873335	9.949353	10.040647	20
9.822830	9.873223	9.949607	10.050393	19
9.822972	9.873110	9.949862	10.050138	18
9.823114	9.872998	9.950116	10.059884	17
9.823255	9.872885	9.950370	10.059630	16
9.823397	9.872772	9.950625	10.059375	15
9.823538	9.872659	9.950879	10.049121	14
9.823680	9.872546	9.951133	10.048867	13
9.823821	9.872434	9.951388	10.048612	12
9.823962	9.872321	9.951642	10.048358	11
9.824104	9.872208	9.951896	10.048104	10
9.824245	9.872094	9.952150	10.047850	9
9.824386	9.871981	9.952404	10.047575	8
9.824527	9.871868	9.952659	10.047341	7
9.824667	9.871755	9.952913	10.047087	6
9.824808	9.871641	9.953167	10.046833	5
9.824949	9.871528	9.953421	10.046579	4
9.825090	9.871414	9.953675	10.046325	3
9.825230	9.871301	9.953929	10.046071	2
9.825370	9.871187	9.954183	10.045817	1
9.825511	9.871073	9.954437	10.045562	0
Co-fine	Sine	*Co-tang.*	Tangent	M

Degree 48.

Canon Triangulorum Logarithmicus.

Degree 42.

M	Sine	*Co-sine*	Tangent	*Co-tang.*
0	9.8255511	9.8710737	9.9544437	10.045562
1	9.8256511	9.8709607	9.9546911	10.045308
2	9.8257911	9.8708467	9.9549451	10.045054
3	9.8259311	9.8707327	9.9551991	10.044800
4	9.8260711	9.8706187	9.9554531	10.044546
5	9.8262111	9.8705047	9.9557071	10.044292
6	9.8263511	9.8703907	9.9559611	10.044038
7	9.8264911	9.8702757	9.9562151	10.043784
8	9.8266311	9.8701617	9.9564691	10.043531
9	9.8267711	9.8700477	9.9567231	10.043276
10	9.8269111	9.8699337	9.9569771	10.043023
11	9.8270491	9.8698187	9.9572311	10.042769
12	9.8271891	9.8697047	9.9574851	10.042515
13	9.8273281	9.8695897	9.9577391	10.042261
14	9.8274671	9.8694747	9.9579931	10.042007
15	9.8276061	9.8693607	9.9582461	10.041753
16	9.8277451	9.8692457	9.9585001	10.041500
17	9.8278841	9.8691307	9.9587541	10.041246
18	9.8280231	9.8690157	9.9590081	10.040992
19	9.8281621	9.8689007	9.9592621	10.040738
20	9.8283011	9.8687857	9.9595151	10.040485
21	9.8284391	9.8686701	9.9597691	10.040231
22	9.8285781	9.8685551	9.9600231	10.039977
23	9.8287161	9.8684391	9.9602771	10.039723
24	9.8288551	9.8683241	9.9605301	10.039469
25	9.8289931	9.8682091	9.9607841	10.039216
26	9.8291311	9.8680931	9.9610381	10.038962
27	9.8292691	9.8679781	9.9612911	10.038608
28	9.8294071	9.8678621	9.9615451	10.038451
29	9.8295451	9.8677471	9.9617991	10.038201
30	9.8296831	9.8676311	9.9620521	10.037947
31	9.8298211	9.8675151	9.9623061	10.037694
32	9.8299591	9.8673991	9.9625601	10.037440
33	9.8300961	9.8672831	9.9628131	10.037187
34	9.8302341	9.8671671	9.9630671	10.036933
35	9.8303721	9.8670511	9.9633201	10.036680
36	9.8305091	9.8669351	9.9635741	10.036426
37	9.8306461	9.8668191	9.9638271	10.036173
38	9.8307841	9.8667031	9.9640811	10.035919
39	9.8309211	9.8665861	9.9643351	10.035665
40	9.8310581	9.8664701	9.9645881	10.035412
41	9.8311951	9.8663531	9.9648421	10.035158
42	9.8313321	9.8662371	9.9650951	10.034905
43	9.8314691	9.8661201	9.9653481	10.034652
44	9.8316061	9.8660041	9.9656021	10.034398
45	9.8317421	9.8658871	9.9658551	10.034144
46	9.8318791	9.8657701	9.9661091	10.033891
47	9.8320151	9.8656531	9.9663621	10.033638
48	9.8321521	9.8655361	9.9666161	10.033384
49	9.8322881	9.8654191	9.9668691	10.033131
50	9.8324251	9.8653021	9.9671221	10.032878
51	9.8325611	9.8651851	9.9673761	10.032624
52	9.8326971	9.8650681	9.9676291	10.032371
53	9.8328331	9.8649501	9.9678831	10.032117
54	9.8329691	9.8648331	9.9681361	10.031864
55	9.8331051	9.8647161	9.9683891	10.031611
56	9.8332411	9.8645981	9.9686431	10.031357
57	9.8333761	9.8644801	9.9688961	10.031104
58	9.8335121	9.8643631	9.9691491	10.030851
59	9.8336481	9.8642451	9.9694031	10.030597
60	9.8337831	9.8641271	9.9696561	10.030344
	Co-sine.	Sine	*Co-tang.*	Tangent

Degree 47.

Degree 43.

Sine	*Co-sine*	Tangent	*Co-tang.*	
9.8337831	9.8641271	9.9696561	10.030344	60
9.8339191	9.8640101	9.9699091	10.030091	59
9.8340541	9.8638921	9.9701621	10.029838	58
9.8341891	9.8637741	9.9704161	10.029584	57
9.8343241	9.8636561	9.9706691	10.029331	56
9.8344601	9.8635371	9.9709221	10.029078	55
9.8345951	9.8634191	9.9711751	10.028827	54
9.8347301	9.8633011	9.9714281	10.028571	53
9.8348651	9.8631831	9.9716821	10.028318	52
9.8349991	9.8630641	9.9719351	10.028065	51
9.8351341	9.8629461	9.9721881	10.027812	50
9.8352691	9.8628271	9.9724411	10.027559	49
9.8354031	9.8627091	9.9726941	10.027306	48
9.8355381	9.8625901	9.9729481	10.027052	47
9.8356721	9.8624711	9.9732011	10.026799	46
9.8358061	9.8623531	9.9734541	10.026546	45
9.8359411	9.8622341	9.9737071	10.026292	44
9.8360751	9.8621151	9.9739601	10.026040	43
9.8362091	9.8619961	9.9742131	10.025787	42
9.8363431	9.8618771	9.9744661	10.025533	41
9.8364771	9.8617571	9.9747191	10.025280	40
9.8366111	9.8616381	9.9749731	10.025027	39
9.8367451	9.8615191	9.9752291	10.024774	38
9.8368781	9.8613991	9.9754791	10.024521	37
9.8370121	9.8612801	9.9757321	10.024268	36
9.8371461	9.8611611	9.9759851	10.024015	35
9.8372791	9.8610411	9.9762381	10.023762	34
9.8374121	9.8609211	9.9764911	10.023509	33
9.8375461	9.8608021	9.9767441	10.023256	32
9.8376791	9.8606821	9.9769971	10.023003	31
9.8378121	9.8605621	9.9772501	10.022750	30
9.8379451	9.8604421	9.9775031	10.022497	29
9.8380781	9.8603221	9.9777561	10.022244	28
9.8382111	9.8602021	9.9780091	10.021991	27
9.8383441	9.8600821	9.9782621	10.021738	26
9.8384771	9.8599621	9.9785151	10.021485	25
9.8386091	9.8598421	9.9787681	10.021232	24
9.8387421	9.8597211	9.9790211	10.020979	23
9.8388751	9.8596011	9.9792741	10.020726	22
9.8390071	9.8594801	9.9795271	10.020473	21
9.8391401	9.8593601	9.9797801	10.020220	20
9.8392721	9.8592391	9.9800331	10.019967	19
9.8394841	9.8591181	9.9802851	10.019714	18
9.8395361	9.8589981	9.9805381	10.019461	17
9.8396681	9.8588771	9.9807911	10.019209	16
9.8398001	9.8587561	9.9810441	10.018956	15
9.8399321	9.8586391	9.9812971	10.018703	14
9.8400641	9.8585141	9.9815501	10.018450	13
9.8401961	9.8583981	9.9818031	10.018197	12
9.8403281	9.8582721	9.9820561	10.017944	11
9.8404591	9.8581501	9.9823091	10.017691	10
9.8405911	9.8580291	9.9825621	10.017438	9
9.8407221	9.8579081	9.9828141	10.017185	8
9.8408541	9.8577861	9.9830671	10.016933	7
9.8409851	9.8576651	9.9833201	10.016680	6
9.8411161	9.8575431	9.9835731	10.016427	5
9.8412471	9.8574211	9.9838261	10.016174	4
9.8413781	9.8573001	9.9840791	10.015921	3
9.8415091	9.8571781	9.9843321	10.015668	2
9.8416401	9.8570561	9.9845841	10.015416	1
9.8417711	9.8569341	9.9848371	10.015163	0
Co-sine	Sine	*Co-tang.*	Tangent	M

Degree 46.

Degree 44.

M	Sine	*Co-fine*	Tangent	*Co-tang.*	
0	9.841771	9.856934	9.984837	10.015162	60
1	9.841902	9.856812	9.985090	10.014910	59
2	9.842033	9.856690	9.985343	10.014657	58
3	9.842163	9.856568	9.985596	10.014404	57
4	9.842294	9.856445	9.985848	10.014151	56
5	9.842424	9.856323	9.986101	10.013899	55
6	9.842555	9.856201	9.986354	10.013646	54
7	9.842685	9.856078	9.986607	10.013393	53
8	9.842815	9.855956	9.986859	10.013140	52
9	9.842945	9.855833	9.987112	10.012888	51
10	9.843076	9.855710	9.987365	10.012635	50
11	9.843206	9.855588	9.987618	10.012382	49
12	9.843336	9.855465	9.987871	10.012129	48
13	9.843465	9.855342	9.988123	10.011877	47
14	9.843595	9.855219	9.988376	10.011624	46
15	9.843725	9.855096	9.988629	10.011371	45
16	9.843855	9.854973	9.988882	10.011118	44
17	9.843984	9.854850	9.989134	10.010866	43
18	9.844114	9.854727	9.989387	10.010613	42
19	9.844243	9.854603	9.989640	10.010360	41
20	9.844372	9.854480	9.989893	10.010107	40
21	9.844502	9.854356	9.990145	10.009855	39
22	9.844631	9.854233	9.990398	10.009602	38
23	9.844760	9.854109	9.990651	10.009349	37
24	9.844889	9.853986	9.990903	10.009096	36
25	9.845018	9.853862	9.991156	10.008844	35
26	9.845147	9.853738	9.991409	10.008591	34
27	9.845276	9.853614	9.991662	10.008338	33
28	9.845404	9.853490	9.991914	10.008086	32
29	9.845533	9.853366	9.992167	10.007833	31
30	9.845662	9.853242	9.992420	10.007580	30
31	9.845790	9.853118	9.992672	10.007328	29
32	9.845919	9.852994	9.992925	10.007075	28
33	9.846047	9.852869	9.993178	10.006822	27
34	9.846175	9.852745	9.993430	10.006569	26
35	9.846304	9.852620	9.993683	10.006317	25
36	9.846432	9.852496	9.993936	10.006064	24
37	9.846560	9.852371	9.994189	10.005811	23
38	9.846688	9.852246	9.994441	10.005559	22
39	9.846816	9.852122	9.994694	10.005306	21
40	9.846944	9.251997	9.994947	10.005053	20
41	9.847071	9.851872	9.995199	10.004801	19
42	9.847199	9.851747	9.995452	10.004548	18
43	9.847327	9.851622	9.995701	10.004295	17
44	9.847454	9.851497	9.995957	10.004043	16
45	9.947582	9.851372	9.996210	10.003790	15
46	9.847709	9.851246	9.996463	10.003537	14
47	9.847836	9.851121	9.996715	10.003285	13
48	9.847964	9.850996	9.996968	10.003032	12
49	9.848091	9.850870	9.997220	10.002779	11
50	9.848218	9.850745	9.997473	10.002527	10
51	9.848345	9.850619	9.997726	10.002274	9
52	9.848472	9.850493	9.997979	10.002021	8
53	9.848599	9.850367	9.998231	10.001769	7
54	9.848726	9.850242	9.998484	10.001516	6
55	9.848852	9.850116	9.998737	10.001263	5
56	9.848979	9.849990	9.998989	10.001011	4
57	9.849106	9.849864	9.999242	10.001758	3
58	9.849232	9.849737	9.999495	10.000505	2
59	9.849359	9.849611	9.999747	10.000253	1
60	9.849485	9.849485	10.000000	10.000000	0
	Co-fine	Sine	*Co-tang.*	Tangent	M

Degree 45.

CHILIADES
DECEM
LOGARITHMORUM;
OR
The LOGARITHMES of all NUMBERS
From an Unite to 10000: Whereby the *Logarithmes* of all *Numbers* under 1000000 may be ſpeedily deduced.

Firſt Compoſed by that Excellent Mathematician

Mr. *HENRY BRIGGS*,
Profeſſor of *Geometry* in the Univerſity of *Oxford*.

And their Uſe now Amplified,

By Captain *SAMUEL STURMY*.

N	Log.	N	Log.	N	Log.	N	Log.	N	Log.
1	0.000000	21	1.322219	41	1.612784	61	1.785330	81	1.908485
2	0.301030	22	1.342422	42	1.623249	62	1.792391	82	1.913814
3	0.477121	23	1.361728	43	1.633468	63	1.799340	83	1.919078
4	0.602060	24	1.380211	44	1.643452	64	1.806180	84	1.924279
5	0.698970	25	1.397940	45	1.653212	65	1.812913	85	1.929419
6	0.778151	26	1.414973	46	1.662758	66	1.819544	86	1.934498
7	0.845098	27	1.431363	47	1.672097	67	1.826075	87	1.939519
8	0.903090	28	1.447158	48	1.681241	68	1.832509	88	1.944482
9	0.954242	29	1.462398	49	1.690196	69	1.838849	89	1.949390
10	1.000000	30	1.477121	50	1.698970	70	1.845098	90	1.954242
11	1.041393	31	1.491361	51	1.707570	71	1.851258	91	1.959041
12	1.079181	32	1.505150	52	1.716003	72	1.857332	92	1.963788
13	1.113943	33	1.518514	53	1.724276	73	1.863323	93	1.968483
14	1.146128	34	1.531479	54	1.732393	74	1.869232	94	1.973128
15	1.176091	35	1.544068	55	1.740362	75	1.875061	95	1.977723
16	1.204120	36	1.556303	56	1.748188	76	1.880813	96	1.982271
17	1.230449	37	1.568202	57	1.755875	77	1.886491	97	1.986771
18	1.255272	38	1.579783	58	1.763428	78	1.892094	98	1.991226
19	1.278753	39	1.591064	59	1.770852	79	1.897627	99	1.995635
20	1.301030	40	1.602060	60	1.778151	80	1.903090	100	2.000000

LONDON:
Printed by *M. Clark*, *Anno Domini* 1678.

N	0	1	2	3	4	5	6	7	8	9	D
100	000000	000434	000868	001301	001734	002166	002598	003029	003461	003891	432
101	004321	004751	005181	005609	006038	006466	006894	007321	007748	008174	428
102	008600	009026	009451	009876	010299	010724	011147	011570	011993	012415	424
103	012837	013259	013679	014100	014521	014940	015359	015779	016197	016616	416
104	017033	017451	017868	018284	018700	019116	019532	019947	020361	020775	416
105	021189	021603	022016	022428	022841	023252	023664	024075	024486	024896	412
106	025306	025715	026125	026533	026942	027349	027757	028164	028571	028978	408
107	029384	029789	030195	030599	031004	031408	031812	032216	032619	033021	404
108	033424	033826	034227	034628	035029	035429	035829	036229	036629	037028	400
109	037426	037825	038223	038620	039017	039414	039811	040207	040602	040998	396
110	041393	041787	042182	042576	042969	043362	043755	044148	044539	044932	393
111	045323	045714	046105	046495	046885	047275	047664	048053	048442	048830	389
112	049218	049603	049993	050379	050766	051153	051538	051924	052309	052694	386
113	053078	053466	053846	054229	054613	054996	055378	055760	056142	056524	382
114	056905	057283	057663	058046	058426	058805	059185	059563	059942	060320	379
115	060698	061075	061452	061829	062206	062582	062958	063333	063709	064083	376
116	064458	064832	065206	065579	065953	066326	066699	067071	067443	067815	372
117	068186	068557	068928	069298	069668	070038	070407	070776	071145	071514	369
118	071882	072249	072617	072985	073352	073718	074085	074451	074816	075182	366
119	075547	075912	076276	076640	077004	077368	077731	078094	078457	478819	363
120	079181	079543	079904	080266	080626	080987	081347	081707	082067	082426	360
121	082785	083144	083503	083861	084219	084576	084934	085291	085647	086004	357
122	086359	086716	087071	087426	087781	088136	088490	088845	089198	089552	355
123	089905	090258	090610	090963	091315	091667	092018	092369	092721	093071	351
124	093422	093772	094122	094471	094820	095169	095518	095866	096215	096562	349
125	096910	097257	097604	097951	098298	098644	098989	099335	099681	100026	346
126	100371	100715	101059	101403	101747	102091	102434	102777	103119	103462	343
127	103804	104146	104487	104828	105169	105510	105851	106191	106531	106871	340
128	107209	107549	107888	108227	108565	108903	109241	109579	109916	110253	338
129	100589	110926	111263	111599	111934	112269	112605	112939	113275	113609	335
130	113943	114277	114611	114944	115278	115611	115943	116276	116608	116939	333
131	117271	117603	117934	118265	118595	118926	119256	119586	119915	120245	330
132	120574	120903	121231	121559	121888	122216	122544	122871	123198	123525	328
133	123852	124178	124504	124830	125156	125481	125806	126131	126456	126781	325
134	127105	127429	127753	128076	128399	128722	129045	129368	129689	130012	323
135	130334	130655	130977	131298	131619	131939	132259	132579	132899	133219	321
136	133539	133858	134177	134496	134814	135133	135451	135769	136086	136403	318
137	136721	136077	137354	137671	137987	138303	138618	138934	139249	139564	315
138	139879	140194	140508	140822	141136	141449	141763	142076	142389	142702	314
139	143015	143327	143639	143951	144163	144574	144885	145196	145507	145818	311
140	146128	146438	146748	147058	147367	147676	147985	148294	148603	148911	309
141	149219	149527	149835	150142	150449	150756	151063	151369	151676	151982	307
142	152288	152594	152899	153205	153509	153815	154119	154423	154728	155032	305
143	155336	155639	155943	156246	156549	156852	157154	157457	157759	158061	303
144	158362	158664	158965	159266	159567	159868	160168	160469	160769	161068	301
145	161368	161667	161967	162266	162564	162863	163161	163459	163758	164055	299
146	164353	164650	164947	165244	165541	165838	166134	166430	166726	167022	297
147	167317	167613	167908	168203	168497	168792	169086	169380	169674	169968	295
148	170262	170555	170848	171142	171434	171726	172019	172311	172603	172895	293
149	173186	173478	173769	174059	174351	174641	174932	175222	175512	175802	291

N	0	1	2	3	4	5	6	7	8	9	D
150	176091	176381	176669	176959	177248	177536	177825	178113	178401	178689	289
151	178977	179264	169552	179839	180126	180413	180699	180986	181272	181558	287
152	181844	182129	182415	182699	182985	183269	183555	183819	184123	184407	285
153	184691	184975	185259	185542	185825	186108	186391	186674	186956	187239	283
154	187521	187803	188084	188366	188647	188928	189209	189490	189771	190051	281
155	190332	190612	190892	191171	191451	191730	192009	192289	192567	192846	279
156	193125	193403	193681	193959	194237	194514	194792	195069	195346	195623	278
157	195899	196176	196453	196729	197005	197281	197556	197832	198107	198382	276
158	198657	198932	199206	199481	199755	200029	200303	200577	200850	201124	274
159	201397	201670	201943	202216	202488	202761	203033	203303	203577	203848	272
160	104119	204391	204663	204934	205204	205475	205746	206016	206286	206556	271
161	206826	207096	207365	207643	207904	208173	208441	20871c	208978	209247	269
162	209515	209783	210051	210319	210586	210853	211121	211388	211654	211921	267
163	212187	212454	212720	212986	213252	213518	213783	214049	214314	214579	266
164	214844	215109	215323	215638	215902	216166	216429	216694	216957	217221	264
165	217484	217747	218010	218273	218536	218798	219060	219323	219585	219846	262
166	220108	220369	210631	220892	221513	221414	221675	21936	222196	222456	261
167	222716	222676	223236	223496	223755	224015	274274	224533	224791	225051	259
168	225309	225568	225827	226084	226342	226599	226858	227115	221372	227629	258
169	227887	228142	228400	228657	228913	229169	229426	229682	229938	230193	256
170	230449	230704	230959	231215	231469	231724	231979	232234	232488	232732	254
171	232996	233250	233504	233757	234011	234264	234517	234770	235023	235276	253
172	235528	235781	236033	236285	236537	236789	237041	237292	237544	237795	252
173	238046	238297	238548	238799	239049	239929	239549	239799	240049	240299	250
174	240549	240799	241048	241297	241546	241795	242044	242293	242541	242789	249
175	243038	243286	243534	243782	244029	244277	244525	244772	245019	245266	248
176	245513	245759	246009	246252	246499	246745	246991	247237	247482	247728	242
177	247973	248219	248464	248709	248954	249198	249443	249687	249932	250176	245
178	250420	250664	350908	251151	251395	251638	251881	252125	252368	252610	243
179	252853	253096	253334	253580	253822	254064	254306	254548	254789	155031	242
180	255273	255514	255755	255996	256237	256477	256718	256958	257198	257438	241
181	257679	257918	258158	258398	258637	258877	159116	250355	259594	259833	239
182	260071	260309	260548	260787	261025	261263	261501	261739	261976	262214	238
183	262451	262688	262925	263162	263399	263636	263873	264109	264346	264582	237
184	264818	265054	265289	265525	265761	265996	266232	266467	266702	266937	235
185	267172	267406	267641	267875	268109	268344	268578	268812	269046	269279	234
186	269513	269746	269979	270213	270446	270679	270912	271144	271377	271609	233
187	271842	272074	272306	272538	272769	273001	273233	273464	273696	273927	232
188	274158	274389	274619	274850	275081	275311	275542	275772	276002	276232	230
189	276462	276692	276921	277151	277379	277609	277838	278067	278296	278525	229
190	278754	278982	279211	279439	276667	279895	280123	280351	280578	280806	228
191	281033	281261	281488	281714	281942	282169	282396	282622	282849	283075	228
192	283301	283527	283753	283979	284205	284431	284656	284882	285107	285332	226
193	285557	285782	286007	286232	286456	286681	286905	287129	287354	287578	225
194	287802	288026	288249	288473	288696	288919	289143	289366	289589	289812	223
195	290035	290257	290479	290702	290925	291147	291369	291591	291813	292034	222
196	292256	292478	292699	292920	293141	293362	293584	293804	294025	294246	221
197	294466	294687	294907	295127	295347	295567	295787	296007	296226	296446	220
198	296665	296884	297104	297323	297542	297761	297979	298198	298416	298635	219
199	298853	299071	299289	299507	299725	199943	300161	300378	300595	300813	218

N	0	1	2	3	4	5	6	7	9	0	D
200	301030	301247	301464	301681	301898	302114	302331	302547	302764	302979	217
201	303196	303412	303628	303844	304059	304275	304491	304706	304921	305136	216
202	305351	305566	305781	305996	306211	206425	306639	306854	307068	307282	215
203	307496	307709	307924	308137	308351	308564	308778	308991	309204	309417	213
204	309630	309843	310056	310268	310481	310693	310906	311118	311329	311542	212
205	311754	311966	312177	312389	312600	312812	313023	313234	313445	313956	211
206	313867	914078	314289	314499	314709	314920	315130	315340	315551	315760	210
207	315970	311180	316389	316599	316809	317018	317227	317436	317646	317854	209
208	318063	318272	318481	318689	318898	319106	319314	319522	319730	319938	208
209	320146	320354	320562	320769	320977	321184	321391	321598	321805	322012	207
210	322219	322426	322633	322839	323046	323252	323458	323665	323871	324977	206
211	324282	324488	324694	324899	325105	325310	325516	325721	325926	326131	205
212	326336	326541	326745	326949	327155	327359	327563	327767	327972	328176	204
213	328379	328583	328787	328991	329194	329398	329601	329805	330008	330211	203
214	330414	330617	330819	331022	331225	331427	331629	341832	332034	332236	202
215	332438	332640	332842	333044	333246	833447	333649	333859	334051	334253	202
216	334454	334655	334856	335057	335257	335458	335658	335859	336059	336259	201
217	336459	336659	336859	337059	337259	337459	337659	337859	338058	338257	200
218	338456	338656	338856	339054	339253	339453	339650	339849	340047	340246	199
219	340444	340642	340841	341039	341237	341435	341632	341830	342028	342225	198
220	342227	342620	342817	343014	343212	343409	343606	343802	343999	344196	197
221	344392	344589	344785	344981	345178	345737	345569	345766	345962	346157	196
222	346353	346549	346744	346939	347135	347330	347525	347720	347915	348110	195
223	348305	348499	348694	348889	349083	349278	349472	349659	349860	350054	194
224	450248	350442	350636	350829	351023	351216	351409	351603	351796	331989	193
225	352183	352375	352568	352761	352954	353147	353339	353532	353724	353916	193
226	354108	354301	354493	354685	354876	355068	355259	355452	355643	355834	192
227	356026	356217	356408	356599	356792	356981	357172	357363	357554	357744	191
228	357935	358125	358506	358699	358696	358886	359076	359266	359456	359646	190
229	359835	360025	360404	360593	360593	360783	360972	361161	361350	361539	189
230	361728	361917	362105	362294	362482	362671	362859	363048	363236	363424	188
231	363612	363799	363988	364176	364363	364551	364739	364926	365113	365301	188
232	365488	365675	365862	366049	366236	366423	366609	366796	366983	367169	187
233	367356	367542	367729	367915	368101	368287	368473	368659	368845	369030	186
234	369216	369401	369587	369772	369958	370143	370328	370513	370698	370882	185
235	371068	371253	371437	371622	371806	371991	372175	372359	372544	372728	184
236	372912	373096	373279	373464	373647	373831	374015	374198	374382	374565	184
237	374748	374932	375115	375298	375481	375664	375846	376029	376212	376394	183
238	376577	376159	376942	377124	377306	377488	377670	377852	378034	378216	182
239	378398	378579	378761	378943	379124	379306	379487	379668	379849	380030	181
240	380211	380392	380573	380754	380934	381115	381296	381476	381656	381837	181
241	382017	382197	382377	382557	382737	382917	383097	383277	383456	383636	180
242	383815	383995	384174	384353	384533	384712	384891	385069	385249	385428	179
243	385606	385785	385964	386142	386321	389499	386677	386856	387034	387212	178
244	387389	387568	387746	387923	388101	388279	388456	388634	388811	388989	178
245	389166	389343	389520	389698	389875	390051	390228	390405	390582	390759	177
246	390935	391112	391288	391464	391641	391817	391993	392169	392345	392521	176
247	392697	392873	393048	393224	393399	393575	393751	393926	394101	394277	176
248	394452	394627	394802	394977	395152	395326	395501	395676	395850	396025	175
249	396199	396374	396548	396722	396896	397071	397245	397419	397592	397766	174

N	0	1	2	3	4	5	6	7	9	0	D
250	397940	398114	398287	398461	398634	398808	398981	399154	399328	399501	173
251	399674	399847	400019	400192	400365	400538	400711	400883	401056	401228	173
252	401401	401573	401745	401917	402089	402261	402433	402605	402777	402949	172
253	403121	403292	403464	403635	403807	403978	404149	404320	404492	404663	171
254	404834	405005	405176	405346	405517	405688	405858	406029	406199	406369	171
255	406540	406710	406881	407051	407221	407391	407561	407731	407901	408070	170
256	408239	408409	408579	408749	408918	409087	409257	409426	409595	409764	169
257	409933	410102	410271	410439	410609	410777	41094	411114	41128	41145	169
258	411619	411788	41195	412124	41229	412461	412629	412796	412964	41313	168
259	413299	413467	413633	413803	413969	414137	413305	414472	414639	414806	167
260	414973	415140	415307	415474	415641	415808	415974	416141	416308	416474	167
261	41664	416807	416973	417139	417306	417472	417638	417804	41796	418135	166
262	418301	418467	41863	418798	418964	419129	419295	419460	419625	41979	165
263	419956	42012	420289	420451	420616	420781	420945	421110	421275	421439	165
264	421604	421768	421933	422097	422261	422426	422589	422754	422918	42308	164
265	423246	423409	423574	423737	423901	424065	424228	424392	424555	424718	164
266	42488	425045	425208	42537	425534	425697	425860	426023	426186	426349	163
267	42651	426674	426836	426999	427161	427324	427486	427648	427811	427973	162
268	42813	428297	42845	428621	42878	428944	429106	429268	429429	429591	162
269	42975	429914	430075	430236	430398	430559	430719	430881	43104	43120	161
270	431364	431525	431685	431846	432007	432167	432328	432488	432649	432809	161
271	43296	433129	433289	433449	433609	433769	433929	434089	434249	434409	160
272	43459	34729	434868	435048	435207	435366	43552	435685	435844	436004	159
273	43616	436322	436481	436639	436799	436957	43711	43727	437433	43759	159
274	43775	437909	438067	438226	438384	43854	43870	43885	439017	439175	158
275	439333	439491	439648	439806	439964	440122	440279	440437	440594	440752	158
276	440909	441066	441224	441381	44153	441695	441852	442009	442166	442323	157
277	44247	442637	442793	442949	443106	443263	443419	443576	44373	443885	157
278	444045	444201	44435	444513	44466	444825	44498	445137	445293	45449	156
279	445604	445759	44591	44607	44622	44638	446537	44669	44684	447003	155
280	447158	447313	447468	447623	447778	447932	448088	44824	448397	448552	155
281	44870	44886	449015	449169	449324	449478	449633	449787	449941	450095	154
282	5024	50403	450557	50711	450865	51018	451172	451326	451479	451633	154
283	451786	451939	452093	452247	452399	45255	452706	452859	453012	453165	153
284	453318	453471	453624	453777	453929	454082	45423	45438	454539	454692	153
285	454845	454997	455149	455302	455454	455606	455758	455910	45606	456214	152
286	456366	456518	456669	456821	456973	45712	457276	457428	457579	457731	152
287	459889	458033	458184	458336	458487	458638	458789	458939	45909	459242	151
288	459392	459543	459694	459845	459995	460146	460296	460447	460597	460748	151
289	460898	461048	461198	461348	461499	461649	461799	461948	462098	462248	150
290	462398	462548	462697	462847	462997	463146	463296	463445	463594	463744	150
291	463893	464042	464191	464340	464489	464639	464787	464936	465085	465234	149
292	465383	465532	465680	465829	465977	466126	466274	466423	466571	466719	149
293	466868	467016	467164	467312	467460	467608	467756	467904	468052	468199	148
294	468347	468495	468643	468790	468798	469085	469233	469380	469527	469675	147
295	469822	469969	470116	470263	470410	470557	470704	470851	470998	471145	147
296	471292	471438	471585	471732	471878	472025	472171	472318	472464	472610	146
297	472756	472903	473049	473195	473341	473487	473633	473779	473925	474071	146
298	474216	474362	474508	474653	474799	474944	475089	475235	475381	475526	146
299	475671	475816	475962	476107	476252	476397	476542	476687	476832	476976	145

N	0	1	2	3	4	5	6	7	8	9	D
300	477121	477266	477411	477555	477699	477844	477989	478133	478278	478422	145
301	478566	478711	478855	478999	479143	479287	479431	479575	479719	479863	144
302	480007	480151	480294	480438	480582	480725	480869	481012	481156	481299	144
303	481443	481586	481729	481872	482016	482159	482302	482445	482588	482731	143
304	482874	483016	483159	483302	483445	483587	483729	483872	484015	484157	143
305	484299	484442	484585	484727	484869	485011	485153	485295	485437	485579	142
306	485721	485863	486005	486147	486289	486430	486572	486714	486855	486997	142
307	487138	487279	487421	487563	487704	487845	487986	488127	488269	488409	141
308	488551	488692	488833	488974	489114	489255	489396	489537	489677	489818	141
309	489958	490099	490239	490379	490520	490661	490801	490941	491081	491222	140
310	491362	491502	491642	491782	491922	492062	492201	492341	492481	492621	140
311	492760	492900	493039	493179	493319	493458	493597	493737	493876	494015	139
312	494155	494294	494433	494572	494711	494850	494989	495128	495267	495406	139
313	495544	495683	495822	495960	496099	496238	496376	496515	496653	496791	139
314	496929	497068	497206	497344	497483	497621	497759	497897	498035	498173	138
315	498311	498448	498586	498724	498862	498999	499137	499275	499412	499549	138
316	499687	499824	499962	500099	500236	500374	500510	500648	500785	500922	137
317	501059	501196	501333	501470	501607	501744	501880	502017	502154	502291	137
318	502427	502564	502700	502837	502973	503109	503246	503382	503518	503655	136
319	503791	503927	504063	504199	504335	504471	504607	504743	504878	505014	136
320	505149	505286	505421	505557	505693	505828	505964	506099	506234	506369	136
321	506505	506640	506776	506911	507046	507181	507316	507451	507586	507721	135
322	507856	507991	508126	508260	508395	508529	508664	508799	508934	509068	135
323	509203	509337	509471	509606	509740	509874	510009	510144	510277	510411	134
324	510545	510679	510813	510947	511081	511215	511349	511482	511616	511749	134
325	511883	512017	512151	512284	512418	512551	512684	512818	512951	513084	133
326	513218	513351	513484	513617	513750	513883	514016	514149	514282	514415	133
327	514548	514681	514813	514946	515079	515211	515344	515476	515609	515741	133
328	515874	516006	516139	516271	516403	516535	516668	516799	516932	517064	132
329	517196	517328	517459	517592	517724	517855	517987	518119	518251	518382	132
330	518514	518646	518777	518909	519040	519171	519303	519434	519566	519697	131
331	519828	519959	520090	520221	520353	520484	520615	520745	520876	521007	131
332	521138	521269	521399	521530	521661	521792	521922	522053	522183	522314	131
333	522444	522575	522705	522835	522966	523096	523226	523356	523486	523616	130
334	523746	523876	524006	524136	524266	524396	524526	524656	524785	524915	130
335	525045	525174	525304	525434	525563	525693	525822	525951	526081	526210	129
336	526339	526469	526598	526727	526856	526985	527114	527243	527372	527501	129
337	527629	527759	527888	528016	528145	528274	528402	528531	528659	528788	129
338	528916	529045	529174	529302	529430	529559	529687	529815	529943	530072	128
339	530199	530328	530456	530585	530712	530839	530968	531096	531223	531351	128
340	531479	531607	531734	531862	531989	532117	532245	532372	532499	532627	128
341	532754	532882	533009	533136	533264	533391	533518	533645	533772	533899	127
342	534026	534153	534280	534407	534534	534661	534787	534914	535041	535167	127
343	535294	535421	535547	535674	535800	535927	536053	536179	536304	536432	126
344	536558	536685	536811	536937	537063	537185	537315	537441	537567	537693	126
345	537819	537945	538071	538197	538322	538448	538574	538699	538825	538951	126
346	539076	539202	539327	539452	539578	539703	539829	539954	540079	540204	125
347	540329	540455	540579	540705	540829	540955	541079	541205	541329	541454	125
348	541579	541704	541829	541953	542078	542203	542327	542452	542576	542701	125
349	542825	542949	543074	543199	543323	543447	543571	543696	543819	543944	124

N	0	1	2	3	4	5	6	7	8	9	D
350	544008	544192	544316	544440	544564	544688	544812	544934	545059	545183	124
351	545307	545431	545555	545678	545802	545925	546049	546172	546296	546419	124
352	546543	546666	546789	546912	547036	547159	547282	547405	547529	547652	123
353	547775	547898	548021	548144	548267	548389	548512	548635	548758	548881	123
354	549003	549126	549249	549371	549494	549616	549739	549861	549984	550106	123
355	550228	550351	550473	550595	550717	550839	550962	551084	551206	551328	122
356	551449	551572	551694	551816	551938	552059	552181	552303	552425	552547	122
357	552668	552789	552911	553033	553155	553276	553398	553519	553640	553762	121
358	553883	554004	554126	554247	554368	554489	554610	554731	554852	554973	121
359	555094	555215	555336	554457	555578	555699	555819	555940	556061	556182	121
360	556303	556423	556544	556664	556785	556905	557026	557146	557267	557387	120
361	557507	557627	557748	557868	557988	558108	558228	558349	558469	558589	120
362	558709	558829	558948	559068	559188	559308	559428	559548	559667	559787	120
363	559907	560026	560146	560265	560385	560504	560624	560742	560863	560982	119
364	561101	561221	561339	561459	561578	561698	561817	561936	562055	562174	119
365	562293	562412	562531	562649	562769	562887	563006	563125	563244	563362	119
366	563481	563599	563718	563837	563955	564074	564192	564311	564429	564548	119
367	564666	564784	564903	56502	565139	565257	565376	565494	565612	565729	118
368	565848	565966	566084	566202	566319	566437	566555	566673	566791	566909	118
369	567026	567144	567262	567379	567497	567614	567732	567849	567967	568084	118
370	568202	568319	568436	568554	568671	568788	568905	569023	569131	569257	117
371	569374	56949	569608	569725	569842	569959	570076	570193	570309	570426	117
372	570543	570659	570776	570893	571009	571126	57124	571359	571476	571592	117
373	571709	571825	571942	572058	572174	572291	572407	572523	572639	572755	116
374	572872	572988	573104	573219	573336	573452	573568	573684	573799	573915	116
375	574031	574147	574263	574379	574494	574609	574726	574841	574957	575072	116
376	575188	575303	575419	575534	575649	575765	575880	575995	576111	576226	115
377	576341	576457	576572	576687	576802	576917	577032	577147	577262	577377	115
378	577492	577607	577722	577836	57795	578066	578181	578295	578409	578525	115
379	578639	578754	578868	578983	579097	579212	579326	579441	579555	579669	114
380	579784	579898	580012	580126	580241	580355	580469	580583	580697	580811	114
381	580925	581039	081153	581267	581382	581495	581608	581722	581836	581949	114
382	582063	582177	582291	582404	582518	582631	582745	582858	582972	583085	114
383	583199	583312	583426	583539	583652	583765	583879	583992	584105	584218	113
384	584331	584444	584587	584670	584783	584896	585009	585122	585235	585348	113
385	585461	585574	585686	585799	585912	586024	586137	586249	586362	586475	113
386	586587	586699	586812	586925	587037	587149	587262	587374	587486	587599	112
387	587711	587823	587935	588047	588159	588271	588384	588496	588608	588719	112
388	588832	588944	589056	589167	589279	589391	589503	589615	589726	589838	112
389	589949	590061	590173	590284	590396	590507	590619	590730	590842	590953	112
390	591065	591176	591287	591399	591509	591621	591732	591843	591955	592066	111
391	592177	592288	592399	592509	592621	592732	592843	592954	593064	593175	111
392	593286	593397	593508	593618	593729	593839	593950	594061	594171	594282	111
393	594393	594503	594614	594724	594834	594945	595055	595165	595276	595386	110
394	595496	595606	595717	595827	595937	596047	596157	596267	596377	596487	110
395	596597	596707	596817	596927	597037	597146	597256	597366	597476	597586	110
396	597695	597805	597914	598024	598134	598243	598353	598462	598572	598681	110
397	598790	598899	599009	599119	599228	599337	599446	599556	599665	599774	109
398	599883	599992	600101	600210	600319	600428	600537	600646	600755	600864	109
399	600973	601082	601191	601299	601408	601517	601625	601734	601842	601951	109

N	0	1	2	3	4	5	6	7	8	9	D
400	602059	602169	602277	602386	602494	602603	602819	602819	602928	603036	108
401	603144	603253	603361	603469	603577	603686	603794	603902	604009	604118	108
402	604226	604334	604442	604550	604658	604766	604874	604982	605089	605197	108
403	605305	605413	605521	605628	605736	705844	605951	606059	606166	606274	108
404	606381	506489	606596	606704	606811	606919	607026	607133	607241	607348	107
405	607455	607562	607669	607777	607884	607991	608098	608205	608312	608419	107
406	608526	608633	608739	608847	608954	609061	609167	609274	609381	609488	107
407	09594	609701	609808	609914	610021	610128	610234	610341	610447	610555	107
408	10660	610767	610873	610979	611086	611192	611298	611405	611511	611617	106
409	611723	611829	611936	612042	612148	612254	612359	612466	612572	612678	106
410	612784	612889	612966	613102	613207	613313	613419	613525	613630	613736	106
411	913841	613947	614053	614159	614264	614369	614475	614581	614686	614792	106
412	914897	615003	615108	615213	615319	615424	615529	615634	615739	615845	105
413	615950	616055	616160	616265	616370	716476	616581	616686	616790	616895	105
414	617000	617105	617210	617315	617419	617525	617629	617734	617839	617943	105
415	618048	618153	618257	618362	618466	618571	618676	618780	618889	618989	105
416	619093	619198	619302	619406	619511	619615	619719	619824	619928	620032	104
417	620136	620240	620344	620448	620552	620656	620760	620864	620968	621072	104
418	621176	621280	621384	621448	621592	621695	621799	621902	622007	622110	104
419	622214	622317	622421	622525	622628	622722	622835	622939	623042	623146	104
420	623249	623353	623456	623559	623663	623766	623869	623973	624076	624179	103
421	624282	624385	624488	624591	624695	624798	624901	625004	625107	625209	103
422	625312	625415	625518	625621	625424	625827	625929	626032	626135	626237	103
423	626340	626443	626546	626648	626751	626853	626956	627058	627161	627263	103
424	927366	627468	627571	627673	627775	627878	627979	728082	628185	628287	102
425	628389	628491	628593	628695	628797	628899	629002	629104	629206	629308	102
426	629409	629512	629613	629715	629817	629919	630021	630123	630224	630326	102
427	630428	630529	630631	630733	630835	630936	631038	631139	631241	631342	102
428	631444	631549	631647	631748	631849	13195	632052	632153	632255	632356	101
429	632457	632559	632659	632761	632862	632963	633064	633165	633266	633367	101
430	633468	633569	633670	633771	633872	633973	634075	634175	634276	634376	100
431	634477	934578	634679	634779	634880	634981	635081	635182	635283	635383	100
432	635484	635584	635685	635785	635886	635986	636087	636187	636288	636388	100
433	636488	636588	636688	636789	636889	639989	637089	637189	637289	637389	100
434	637489	637589	637689	637789	637889	637989	638089	638189	638289	638389	99
435	638489	638589	638689	638789	638888	638988	639088	639188	639287	639387	99
436	639486	639586	639686	639785	639885	639984	640084	640183	640283	640382	99
437	640481	640581	640680	640779	640879	640978	641077	641177	641276	641375	99
438	641475	641573	641672	641771	641871	641969	642069	642168	642267	642366	99
439	642465	642563	642662	642761	642860	642959	643058	633156	643255	643354	99
440	643453	643551	643650	643749	643847	643946	644044	644143	644242	644340	98
441	644439	644537	644636	644734	644833	644931	645029	645127	645226	645324	98
442	645422	645521	645619	645717	645815	645913	646011	646109	646208	646306	98
443	646404	646502	646599	646698	646796	646894	646992	647089	647187	647285	98
444	647383	647481	647579	647676	647774	647872	647969	648067	648165	648262	98
445	648360	648458	648555	648653	648750	648848	648945	649043	649140	649237	97
446	649335	649432	649529	649627	649724	649821	649919	650016	650113	650210	97
447	650308	650405	650502	650599	650696	650793	650890	650987	651084	651181	97
448	651278	951375	651472	651569	651666	651762	551859	651956	652053	652149	97
449	652246	652343	652439	652536	652633	652729	652826	652923	953019	653116	97

The Table of Logarithms.

N	0	1	2	3	4	5	6	7	8	9	D
450	653213	653309	653405	653502	653598	653695	653791	653888	653984	654080	96
451	654177	654273	654369	654465	654562	654658	654754	654850	654946	655042	96
452	655138	655235	655331	655427	655523	655619	655715	655810	655906	656002	96
453	656098	656194	656289	656386	656482	656577	656673	656769	656864	656960	96
454	657056	657152	657247	657343	657438	657534	657629	657725	657820	657916	96
455	658011	658107	658202	658298	658393	658488	658584	658679	658774	658869	95
456	658965	659060	659155	659250	659346	659441	659536	659630	659726	659821	95
457	659916	660011	660106	660201	660296	660391	660486	660581	660676	660771	95
458	660865	660960	661055	661149	661245	661339	661434	661529	661623	661718	95
459	661813	661907	662002	662096	662191	662286	662380	662475	662569	662663	95
460	662758	662852	662947	663041	663135	663229	663324	663418	663512	663607	94
461	663701	663795	663889	663983	664078	664172	664266	664359	664454	664548	94
462	664642	664736	664829	664924	665018	665112	665206	665299	665393	665487	94
463	665581	665675	665769	665862	665956	666049	666143	666237	666331	666424	94
464	666518	666611	666705	666799	666892	666986	667079	667173	667266	667359	94
465	667453	667546	667639	667733	667826	667919	668013	668106	668199	668293	93
466	668386	668479	668572	668665	668759	668852	668945	669038	669131	669224	93
467	669317	669409	669503	669596	669689	669782	669875	669967	670060	670153	93
468	670246	670339	670431	670524	670617	670709	670802	670895	670988	671080	93
469	671173	671265	671358	671451	671543	671636	671728	671821	671913	672005	93
470	672098	672190	672283	672375	672467	672559	672652	672744	672836	672929	92
471	673021	673113	673205	673297	673389	673482	673574	673666	673758	673849	92
472	673942	674034	674126	674218	674309	674402	674494	674586	674677	674769	92
473	674861	674953	675045	675137	675228	675319	675412	675503	675595	675687	92
474	675778	675869	675962	676053	676145	676236	676328	676419	676511	676602	92
475	676694	676785	676876	676968	677059	677151	677242	677333	677424	677516	91
476	677607	677698	677789	677881	677972	678063	678154	678245	678335	678427	91
477	678518	678609	678700	678791	678882	678973	679064	679155	679246	679337	91
478	679428	679519	679609	679700	679791	679882	679972	680063	680154	680245	91
479	680336	680426	680517	680607	680698	680789	680879	680969	681060	681151	91
480	681241	681332	681422	681513	681603	681693	681784	681874	681964	682055	90
481	682145	682235	682326	682416	682506	682596	682686	682777	682867	682957	90
482	683047	683137	683227	683317	683407	683497	683587	683677	683767	683857	90
483	683947	684037	684127	684217	684307	684396	684486	684576	684666	684756	90
484	684845	684935	685025	685114	685204	685294	685383	685473	685563	685652	90
485	685742	685831	685921	686010	686099	686189	686279	686368	686458	686547	89
486	686636	686726	686815	686904	686994	687083	687172	687261	687351	687439	89
487	687529	687618	687707	687796	687885	687975	688064	688153	688242	688331	89
488	688419	688509	688598	688687	688776	688865	688953	689042	689131	689220	89
489	689309	689398	689486	689575	689664	689753	689841	689930	690019	690107	89
490	690196	690285	690373	690462	690550	690639	690728	690816	690905	690993	89
491	691081	691169	691258	691347	691435	691524	691612	691700	691789	691877	88
492	691965	692053	692142	692229	692318	692406	692494	692583	692671	692759	88
493	692847	692935	693023	693111	693199	693287	693375	693463	693551	693639	88
494	693727	693815	693903	693991	694078	694166	694254	694342	694429	694517	88
495	694605	694693	694781	694868	694956	695044	695131	695219	695307	695394	88
496	695482	695569	695657	695744	695832	695919	696007	696094	696182	696269	87
497	696356	696444	696531	696618	696706	696793	696880	696968	697055	697142	87
498	697229	697317	697404	697491	697578	697665	697752	697839	697926	698014	87
499	698101	698188	698275	698362	698449	698535	698622	698709	698706	698883	87

The Table of Logarithms.

N	0	1	2	3	4	5	6	7	8	9	D
500	698970	699057	699144	699281	699317	699404	699491	699578	699664	699751	87
501	699838	699924	700011	700098	700184	700271	700358	700444	700531	700617	87
502	700704	700790	700877	700963	701049	701136	701222	701309	701395	701482	86
503	701568	701654	7 1741	701827	701913	701999	702086	702172	702258	702344	86
504	702430	702517	702603	702689	702775	702861	702947	703033	703119	703205	86
505	703291	703377	703463	703549	703635	703721	703807	703893	703979	704065	86
506	704151	704236	704322	704408	704494	704579	704665	704751	704837	704922	86
507	705008	705094	705179	705265	705350	705436	705522	705607	705693	705778	86
508	705863	705949	706035	706120	706206	706291	706376	706462	706547	706632	85
509	706718	706803	706888	706974	707059	707144	707219	707315	707399	707485	85
510	707570	707655	707740	707826	707911	707996	708081	708166	708251	708336	85
511	708421	708506	708591	708676	708761	708846	708931	709015	709100	709185	85
512	709269	709355	709439	709524	709609	709694	709779	709863	709948	710033	85
513	710117	710202	710287	710371	710456	710540	710625	710709	710794	710879	85
514	710963	711048	711132	711217	711301	711385	711469	711554	711639	711723	84
515	711807	711892	711976	712060	712144	712229	712313	712397	712481	712566	84
516	712649	712734	712818	712902	712986	713070	713154	713238	713323	713407	84
517	713491	713575	713659	713742	713826	713910	713994	714078	714162	714246	84
518	714329	714414	714497	714581	714665	714749	714833	714916	714999	715084	84
519	715167	715251	715335	715418	715501	715586	715669	715753	715836	715919	84
520	716003	716087	716170	716254	716337	716421	716504	716588	716671	716754	83
521	716838	716921	717004	717088	717171	717254	717338	717421	717504	717587	83
522	717671	717754	717837	717920	718003	718086	718169	718253	718336	718419	83
523	718502	718585	718668	718751	718834	718917	718999	719083	719165	719248	83
524	719331	719414	719497	719579	719663	719745	719828	719911	719994	720077	83
525	720159	720242	720325	720407	720490	720573	720655	720738	720821	720903	83
526	720986	721068	721151	721233	721316	721398	721481	721563	721646	721728	82
527	721811	721893	721975	722058	722140	722222	722305	722387	722469	722552	82
528	722634	722716	722798	722881	722963	723045	723127	723209	723291	723374	82
529	723456	723538	723619	723702	723784	723866	723948	724029	724112	724194	82
530	724276	724358	724439	724522	724604	724685	724767	724849	724931	725013	82
531	725095	725176	725258	725339	725422	725503	725585	725667	725748	725829	82
532	725912	725993	726075	726156	726238	726319	726401	726483	726564	726646	82
533	726727	726809	726890	726972	727053	727134	727216	727297	727379	727459	81
534	727541	727623	727704	727785	727866	727948	728029	728110	728191	728273	81
535	728354	728435	728516	728597	728678	728759	728841	728922	729003	729084	81
536	729165	729246	729327	729408	729489	729569	729651	729732	729813	729893	81
537	729974	730055	730136	730217	730298	730378	730459	730540	730621	730702	81
538	730782	730863	730944	731024	731105	731186	731266	731347	731423	731508	81
539	731589	731669	731749	731830	731911	731991	732072	732152	732233	732313	81
540	732394	732474	732555	732635	732715	732796	732876	732956	733037	733117	80
541	733197	733278	733358	733438	733518	733598	733679	733759	733839	733919	80
542	733999	734079	734159	734239	734319	734399	734479	734559	734639	734719	80
543	734799	734879	734959	735039	735119	735199	735279	735359	735439	735519	80
544	735599	735679	735759	735838	735918	735998	736078	736157	736237	736317	80
545	736397	736476	736556	736635	736715	736795	736874	736954	737034	737113	80
546	737192	737272	737352	737431	737511	737590	737669	737749	737829	737908	79
547	737987	738067	738146	738225	738305	738384	738463	738543	738622	738701	79
548	738781	738859	738939	739018	739097	739177	739256	739335	739414	739493	79
549	739572	739651	739731	739809	739889	739968	740047	740126	740205	740284	79

N	0	1	2	3	4	5	6	7	8	9	D
550	740363	740442	740521	740599	740678	740757	740836	740915	740994	741073	79
551	741152	741230	741309	741388	741467	741546	741624	741703	741782	741860	79
552	741939	742018	742096	742175	742254	742332	742411	742489	742568	742647	79
553	742725	742802	742882	742961	743039	743118	743196	743275	743353	743431	78
554	7435 9	743588	743667	743745	743823	743902	743979	744058	744136	744215	78
555	744293	744371	744449	744528	744606	744684	744762	744840	744919	744997	78
556	745075	745153	745231	745309	745387	745465	745543	745621	745699	745777	78
557	745855	745933	746011	746089	746167	746245	746323	746401	746479	746556	78
558	746634	746712	746789	746868	746945	747023	747101	747179	747256	747334	78
559	747412	747489	747567	747645	747722	747800	747878	747955	748033	748110	78
560	748188	748266	748343	748421	748498	748576	748653	748731	748808	748885	77
561	748963	749040	749118	749195	749272	749349	749427	749504	749582	749659	77
562	749736	749814	749891	749968	750045	750123	750199	750277	750354	750431	77
563	750508	750586	750663	750739	750817	750894	750971	751048	751125	751202	77
564	751279	751356	751433	751510	751587	751664	751741	751818	751895	751972	77
565	752048	752125	752202	752279	752356	752433	752509	752586	752663	752739	77
566	752816	752893	752969	753047	753123	753199	753277	753353	753429	753506	77
567	753583	753659	753736	753813	753889	753966	754042	754119	754195	754272	77
568	754348	754425	754501	754578	754654	754730	754807	754883	754959	755036	76
569	755112	755189	755265	755341	755417	755494	755569	755646	755722	755799	76
570	755875	755951	756027	756103	756179	756256	756332	756408	756484	756560	76
571	756636	756712	756788	756864	756940	757016	757092	757168	757244	757320	76
572	757396	757472	757548	757627	757699	757775	757851	757927	758003	758079	76
573	758155	758230	758306	758382	758458	758533	758609	758685	758761	758836	76
574	758912	758988	759063	759139	759214	759290	759366	759441	759517	759592	76
575	759668	759743	759819	759894	759969	760045	760121	760196	760272	760347	75
576	760422	760498	760573	760649	760723	760799	760875	760949	761025	761101	75
577	761176	761251	761326	761402	761477	761552	761627	761702	761778	761853	75
578	761928	762003	762078	762153	762228	762303	762378	762453	762529	762604	75
579	762679	762754	762829	762904	762978	763053	763128	763203	763279	763353	75
580	763428	763503	763578	763653	763727	763802	763877	763952	764027	764101	75
581	764176	764251	764326	764400	764475	764549	764624	764699	764774	764848	75
582	764923	764998	765072	765147	765221	765296	765370	765445	765519	765594	75
583	765669	765743	765818	765892	765966	766041	766115	766189	766264	766338	74
584	766413	766487	766562	766636	766710	766785	766859	766933	767007	767082	74
585	767156	767230	767304	767379	767453	767527	767601	767675	767749	767823	74
586	767898	767972	768046	768119	768194	768268	768342	768416	768490	768564	74
587	768638	768712	768786	768860	768934	769008	769082	769156	769229	769303	74
588	769377	769451	769525	769599	769673	769746	769820	769894	769968	770042	74
589	770115	770189	770263	770336	770410	770484	770557	770631	770705	770778	74
590	770852	770926	770999	771073	771146	771219	771293	771367	771440	771514	74
591	771587	771661	771734	771808	771881	771955	772028	772102	772175	772248	73
592	772322	772395	772468	772542	772615	772688	772762	772835	772908	772981	73
593	773055	773128	773201	773274	773348	773421	773494	773567	773640	773713	73
594	773786	773859	773933	774006	774079	774152	774225	774298	774371	774444	73
595	774517	774589	774663	774736	774809	774882	774955	775028	775100	775173	73
596	775246	775319	775392	775465	775538	775610	775683	775756	775829	775902	73
597	775974	776047	776119	776193	776265	776338	776411	776483	776556	776629	73
598	776701	776774	776846	776919	776992	777064	777137	777209	777282	777354	73
599	777427	777499	777572	777644	777717	777789	777862	777934	778006	778079	72

The Table of Logarithms.

N	0	1	2	3	4	5	6	7	8	9	D
600	778151	778224	778296	778368	778441	778513	778585	778658	778729	778802	72
601	778874	778947	779019	779091	779163	779236	779308	779380	779452	779524	72
602	779596	779669	779741	779813	779884	779957	780029	780101	780173	780245	72
603	780317	780389	780461	780533	780605	780677	780749	780821	780893	780965	72
604	781037	781109	781181	781253	781324	781396	781468	781539	781612	781684	72
605	781755	781827	781899	781971	782042	782114	782186	782258	782329	782801	72
606	782473	782544	782616	782688	782759	782831	782902	782974	783046	783117	72
607	783189	783260	783332	783403	783475	783546	783618	783689	783761	783832	71
608	783904	783975	784046	784118	784189	784261	784332	784403	784475	784546	71
609	784617	784689	784759	784831	784902	784974	785045	785116	785187	785259	71
610	785329	785401	785472	785543	785615	785686	785757	785828	785899	785970	71
611	786041	786112	786183	786254	786325	786396	786467	786538	786609	786680	71
612	786751	786822	786893	786964	787035	787106	787177	787248	787319	787389	71
613	787460	787531	787602	787673	787744	787815	787885	787956	788017	788098	71
614	788164	788239	788309	788381	788451	788522	788593	788663	788734	788804	71
615	788875	788946	789016	789087	789157	789228	789299	789369	789439	789510	71
616	789581	789651	789722	789792	789863	789933	790004	790074	790144	790215	70
617	790285	790356	790426	790496	790567	790637	790707	790778	790848	790918	70
618	790988	791059	791129	791199	791269	791339	791409	791480	791550	791620	70
619	791691	791761	791831	791901	791971	792041	792111	792181	792252	792322	70
620	792392	792462	792532	792602	792672	792742	792812	792882	792952	793022	70
621	793092	793162	793231	793301	793371	793441	793511	793581	793651	793721	70
622	793791	793860	793930	793999	794069	794139	794209	794279	794349	794418	70
623	794488	794558	794627	794697	794767	794836	794906	794976	795045	795115	70
624	795185	795254	795324	795393	795463	795532	795602	795672	795741	795810	70
625	795880	795949	796019	796088	796158	796227	796297	796366	796436	796505	69
626	796574	796644	796713	796782	796852	796921	796990	797059	797129	797198	69
627	797268	797337	797406	797475	797545	797614	797683	797752	797821	797890	69
628	797959	798029	798098	798167	798236	798305	798374	798443	798513	798582	69
629	798651	798719	798789	798858	798927	798996	799065	799134	799203	799272	69
630	799341	799409	799478	799547	799616	799685	799754	799823	799892	799961	69
631	800029	800098	800167	800236	800305	800373	800442	800511	800579	800648	69
632	800717	800786	800854	800923	800992	801061	801129	801198	801266	801335	69
633	801404	801472	801541	801609	801678	801747	801815	801884	801952	802021	69
634	802089	802158	802226	802295	802363	802432	802500	802568	802637	802705	68
635	802774	802842	802910	802979	803047	803116	803184	803252	803321	803389	68
636	803457	803525	803594	803662	803730	803798	803867	803935	804003	804071	68
637	804139	804208	804276	804344	804412	804480	804548	804616	804685	804753	68
638	804821	804889	804957	805025	805093	805161	805229	805297	805365	805433	68
639	805501	805569	805637	805705	805773	805841	805908	805976	706044	806112	68
640	806179	806248	866316	806384	806451	806519	806587	806655	806723	806790	68
641	806858	806926	806994	807061	807129	807197	807264	807332	807399	807467	68
642	807535	807603	807670	807738	807806	807873	807941	808008	808076	808143	68
643	808211	808279	808346	808414	808481	808549	808616	808684	808751	808818	67
644	808886	808953	809021	809088	809156	809223	809290	809358	809425	809492	67
645	809559	809627	809694	809762	809829	809866	809964	810031	810098	810165	67
646	810233	810299	810367	810434	810501	810569	810636	810703	810770	810837	67
647	810904	810971	811039	811106	811173	811239	811307	811374	811441	811508	67
648	811575	811642	811709	811776	811843	811909	811977	812044	812111	812178	67
649	812245	812312	812379	812445	812512	812579	812646	812713	812779	812847	67

N	0	1	2	3	4	5	6	7	8	9	D
650	812913	812980	813047	813114	813181	813247	813314	813381	813448	813514	67
651	813581	813648	813714	813781	813848	813914	813981	814048	814114	814181	67
652	814248	814314	814381	814447	814514	814581	814647	814714	814780	814847	67
653	814913	814979	815046	815113	815129	815246	815312	815378	815445	815511	66
654	815578	815644	815711	815777	815843	815909	815976	816042	816109	816175	66
655	816241	816308	816374	816440	816506	816573	816639	816705	816771	816838	66
656	816904	816910	817036	817102	817169	817235	817301	817367	817433	817499	66
657	817565	817631	817698	817764	817829	817896	817962	818028	818094	818159	66
658	818226	818292	818358	818424	818489	818556	818622	818688	818754	818819	66
659	818885	818951	819037	819083	819149	819215	819281	819346	819412	819478	66
660	819543	819609	819676	819741	819807	819873	819939	820004	820070	820136	66
661	820201	820267	820333	820399	820464	820529	820595	820661	820727	820792	66
662	820858	820924	820989	821055	821120	821186	821251	821317	821382	821448	66
663	821514	821509	821645	821709	821775	821841	821906	821972	822037	822103	65
664	822168	822233	822299	822364	822429	822495	822560	822626	822691	822756	65
665	822822	822887	822952	823018	823083	823148	823213	823279	823344	823409	65
666	823474	823539	823605	823669	823735	823800	823865	823930	823996	824061	65
667	824126	824191	824256	824321	824386	824451	824516	824581	824646	824711	65
668	824776	824841	824906	824971	825036	825101	825166	825231	825296	825361	65
669	825426	825491	825556	825621	825686	825751	825815	825880	825945	826009	65
670	826075	826139	826204	826269	826334	826399	826464	826528	826593	826658	65
671	826723	826787	826852	826917	826981	827046	827111	827175	827239	827305	65
672	827369	827434	827499	827563	827628	827692	827757	827822	827886	827951	65
673	828015	828079	828144	828209	828273	828338	828402	828467	828531	828595	64
674	828659	828724	828789	828853	828918	828982	829046	829111	829175	829239	64
675	829304	829368	829432	829497	829561	829625	829689	829754	829818	829882	64
676	829947	830011	830075	830139	830204	830268	830332	830396	830460	830525	64
677	830589	830653	830717	830781	830845	830909	830973	831037	831102	831166	64
678	831229	831294	831358	831422	831486	831549	831614	831678	831742	831806	64
679	831869	831934	831998	832062	832126	832189	832253	832317	832381	832445	64
680	832509	832573	832637	832700	832764	832828	832892	832956	833019	833083	64
681	833147	833211	833275	833338	833402	833466	833529	833593	833657	833721	64
682	833784	833848	833912	833975	834039	834103	834166	834229	834294	834357	64
683	834421	834484	834548	834611	834675	834739	834802	834866	834929	834993	64
684	835056	835119	835183	835247	835310	835373	835437	835500	835564	835627	63
685	835691	835754	835817	835881	835944	836007	836071	836134	836197	836261	63
686	836324	836387	836451	836514	836577	836641	836704	836767	836830	836894	63
687	836957	837019	837083	837146	837209	837273	837336	837399	837462	837525	63
688	837588	837652	837715	837777	837841	837904	837967	838030	838093	838156	63
689	838219	838282	838345	838408	838471	838534	838597	838660	838723	838786	63
690	838849	838912	838975	839038	839101	839164	839227	839289	839352	839415	63
691	839478	839541	839604	839667	839729	839792	839855	839918	839981	840043	63
692	840106	840169	840232	840294	840357	840419	840482	840545	840608	840671	63
693	840733	840796	840859	840921	840984	841049	841109	841172	841234	841297	63
694	841359	841423	841485	841547	841609	841672	841735	841797	841859	841922	63
695	841985	842047	842109	842172	842235	842297	842359	842432	842484	842547	62
696	842609	842672	842734	842796	842859	842921	842983	843046	843108	843170	62
697	843233	843295	843357	843419	843482	843544	843606	843669	843731	843293	62
698	843855	843918	843979	844042	844104	844166	844229	844291	844353	844415	62
699	844477	844539	844601	844664	844726	844788	844849	844912	844974	845036	62

N	0	1	2	3	4	5	6	7	8	9	D
700	845098	845160	845222	845284	845346	845408	845470	845532	845594	845656	62
701	845718	845779	845842	845904	845966	846028	846089	846151	846213	846275	62
702	846337	846399	846461	846523	846585	846646	846708	846769	846832	846894	62
703	846955	847017	847079	847141	847202	847264	847326	847388	847449	847511	62
704	847573	847634	847696	847758	847819	847881	847943	848004	848067	848128	62
705	848189	848251	848312	848374	848435	848497	848559	848620	848682	848743	62
706	848805	848866	848928	848989	849051	849112	849174	849235	849297	849358	61
707	849419	849481	849542	849604	849665	849726	849788	849849	849911	849972	61
708	850033	850095	850156	850217	850279	850339	850401	850462	850524	850585	61
709	850646	850707	850769	850829	850891	850952	851014	851075	851136	851197	61
710	851258	851319	851381	851442	851503	851564	851625	851686	851747	851809	61
711	851869	851931	851992	851053	852114	852175	852236	852297	852358	852419	61
712	852479	832541	852602	852663	852724	852785	852846	852907	852968	853029	61
713	853089	853150	853211	853272	853333	853394	853455	853516	853577	853637	61
714	853698	853759	853819	853881	853941	854002	854063	854124	854185	854245	61
715	854306	854367	854428	854488	854549	854609	854670	854731	854792	854852	61
716	854913	854974	855034	855095	855156	855216	855277	855337	855398	855459	61
717	855519	855579	855640	855701	855761	855822	855882	855943	856003	856064	61
718	856124	856185	856245	856306	856366	856427	856487	856548	856608	856668	60
719	856729	856789	856849	856910	856970	857031	857091	857152	857212	857272	60
720	857332	857393	857453	857513	857574	857634	857694	857755	857815	857875	60
721	857935	857995	858056	858116	858176	858236	858297	858357	858417	858477	60
722	858537	858597	858657	858718	858778	858838	858898	858958	859018	859078	60
723	859138	859198	859258	859318	859379	859439	859499	859559	859619	859679	60
724	859739	859799	859859	859918	859978	860038	860098	860158	860218	860278	60
725	860338	860398	860458	860518	860578	860637	860697	860757	860817	860877	60
726	860937	860996	861056	861116	861176	861236	861295	861355	861415	861475	60
727	861534	861594	861654	861714	861773	861833	861893	861952	862012	862072	60
728	862131	862191	862251	862310	862369	862429	862489	862549	862608	862668	60
729	862728	862787	862847	862906	862966	863025	863085	863144	863204	863263	60
730	863323	863382	863442	863501	863561	863620	863679	863739	863799	863858	59
731	863917	863977	864036	864096	864155	864214	864274	864333	864392	864452	59
732	864511	864570	864629	864689	864748	864808	864867	864926	864985	865045	59
733	865104	865163	865222	865282	865341	865400	865459	865519	865578	865637	59
734	865696	865755	865814	865874	865933	865992	866051	866110	866169	866228	59
735	866187	866346	866405	866465	866524	866583	866642	866701	866759	866819	59
736	866878	866937	866996	867055	867114	867173	867232	867291	867349	867409	59
737	867467	867526	867585	867644	867703	867762	867821	867879	867939	867998	59
738	868056	868115	868174	868233	868292	868350	868409	868468	868527	868586	59
739	868643	868703	868762	868821	868879	868938	868997	869056	869114	869173	59
740	869232	869290	869349	869408	869466	869525	869584	869642	869701	869759	59
741	869818	869877	869935	869994	870053	870111	870169	870228	870287	870345	59
742	870404	870462	870521	870579	870638	870696	870755	870813	870872	870930	58
743	870989	871047	871106	871164	871223	871281	871339	871398	871456	871515	58
744	871573	871631	871689	871748	871806	871865	871923	871981	872039	872098	58
745	872156	872215	872273	872331	872389	872448	872506	872564	872622	872681	58
746	872739	872797	872855	872913	872972	873029	873088	873146	873204	873262	58
747	873321	873379	873437	873495	873553	873611	873669	873727	873785	873844	58
748	873902	873959	874018	874076	874134	874192	874249	874308	874366	874424	58
749	874482	874539	874598	874656	874714	874772	874829	874888	874945	875003	58

N	0	1	2	3	4	5	6	7	8	9	D
750	875061	875119	875177	875235	875293	875351	875409	875466	875524	875582	58
751	875639	875698	875756	875813	875871	875929	875987	876045	876102	876160	58
752	876218	876276	876333	876391	876449	876507	876564	876622	876679	876737	58
753	876795	876853	876910	876968	877026	877083	877141	877199	877256	877314	58
754	877371	877429	877487	877544	877602	877659	877717	877774	877832	877889	58
755	877947	878004	878062	878119	878177	878234	878292	878349	878407	878464	57
756	878522	878579	878637	878694	878752	878808	878866	878924	878981	879039	57
757	879096	879153	879211	879268	879325	879382	879459	879497	879555	879612	57
758	879669	879726	879784	879841	879898	879955	880013	880070	880127	880185	57
759	880242	880299	880356	880413	880471	880527	880585	880642	880699	880756	57
760	880814	880871	880928	880985	881042	881099	881156	881213	881271	881328	57
761	881385	881442	881499	881556	881613	881669	881727	881784	881841	881898	57
762	881955	882012	882069	882126	882183	882239	882297	882354	882411	882468	57
763	882525	882581	882638	882695	882752	882809	882866	882923	882979	883037	57
764	883093	883050	883207	883264	883321	883377	883434	883491	883548	883605	57
765	883661	883718	883775	883832	883888	883945	884002	884059	884115	884172	57
766	884229	884285	884342	884398	884455	884512	884569	884625	884682	884739	57
767	884795	884852	884909	884965	885022	885078	885135	885192	885248	885305	57
768	885361	885418	885474	885531	885587	885644	885700	885757	885813	885869	57
769	885926	885983	886039	886096	886152	886209	886265	886321	886378	886434	56
770	886491	886547	886604	886659	886716	886773	886829	886885	886941	886998	56
771	887054	887111	887167	887223	887279	887336	887392	887449	887505	887561	56
772	887617	887674	887720	887786	887842	887898	887955	888011	888067	888123	56
773	888179	888236	888292	888348	888404	888460	888516	888573	888629	888685	56
774	888741	888797	888853	888909	888965	889021	889077	889134	889189	889246	56
775	889302	889358	889414	889469	889526	889582	889638	889694	889749	889806	56
776	889862	889918	889974	890029	890086	890141	890197	890253	890309	890365	56
777	890421	890477	890533	890589	890645	890700	890756	890812	890868	890924	56
778	890979	891035	891091	891147	891203	891259	891314	891370	891426	891482	56
779	891537	891593	891649	891705	891760	891816	891872	891928	891983	892039	56
780	892095	892150	892206	892262	892317	892373	892429	892484	892539	892595	56
781	892651	892707	892762	892818	892873	892929	892985	893040	893096	893151	56
782	893207	893262	893318	893373	893429	893484	893539	893595	893651	893706	56
783	893762	893817	893873	893928	893984	894039	894094	894149	894205	894261	55
784	894316	894371	894427	894482	894538	894593	894648	894704	894759	894814	55
785	894869	894925	894980	895036	895091	895146	895201	895257	895312	895367	55
786	895423	895478	895533	895588	895644	895699	895754	895809	895864	895919	55
787	895975	896029	896085	896140	896195	896251	896306	896361	896416	896471	55
788	896526	896581	896636	896692	896747	896802	896857	896912	896967	897022	55
789	897077	897132	897187	897242	897297	897352	897407	897462	897517	897572	55
790	897627	897682	897737	897792	897847	897902	897957	898012	898067	898122	55
791	898176	898231	898286	898341	898396	898451	898506	898561	898615	898670	55
792	898725	898780	898835	898889	898944	898999	899054	899109	899164	899218	55
793	899273	899328	899383	899437	899492	899547	899602	899656	899711	899766	55
794	899821	899875	899929	899985	900039	900094	900149	900203	900258	900312	55
795	900367	900422	900476	900531	900586	900640	900695	900749	900804	900859	55
796	900913	900968	901022	901077	901131	901186	901240	901295	901349	901404	55
797	901458	901513	901567	901622	901676	901731	901785	901839	901894	901948	54
798	902003	902057	902112	902166	902221	902275	902329	902384	902438	902492	54
799	902547	902601	902655	902709	902764	902818	902873	902927	902981	903036	54

N	0	1	2	3	4	5	6	7	8	9	D
800	903089	903144	903199	903253	903307	903361	903416	903469	903524	903578	54
801	903633	903687	903741	903795	903849	903904	903956	904012	904066	904120	54
802	904174	904229	904283	904337	904391	904445	904499	904553	904607	904661	54
803	904716	904769	904824	904878	904932	904986	905039	905094	905148	90520:	54
804	905256	905310	905364	905418	905472	905526	905580	905634	905688	90574	54
805	905796	905849	905904	905958	906012	906066	906119	906173	906227	906281	54
806	906335	906389	906443	906497	906551	906604	906658	906712	906766	906819	54
807	906874	906927	907981	907035	907089	907143	907196	907250	907304	907358	54
808	907411	907465	907519	907573	907626	907680	907734	907787	907841	907895	54
809	907949	908002	908056	908109	908163	908217	908270	908324	908378	908431	54
810	908485	908539	908592	908646	908699	908753	908807	908860	908914	908967	54
811	909021	909074	909128	909181	909235	909289	909342	909396	909449	909503	54
812	909556	909609	909663	909716	909769	909823	909877	909930	909984	910037	53
813	910091	910144	910197	910251	910304	910358	910411	910464	910518	910571	53
814	910624	910678	910731	910784	910838	910891	910944	910998	911051	911104	53
815	911158	911211	911263	911317	911371	911424	911477	911530	911584	911637	53
816	911690	911743	911797	911849	911903	911956	912009	912063	912116	912169	53
817	912222	912275	912323	912381	912435	912488	912541	912594	912647	912700	53
818	912753	912806	912859	912913	912966	913019	913072	913125	913178	913231	53
819	913284	913337	913389	913443	913496	913549	913602	913655	913708	913761	53
820	913814	913867	913919	913973	914026	914079	914132	914184	914237	914290	53
821	914343	914396	914449	914502	914555	914608	914660	914713	914766	914819	53
822	914872	914925	914977	915030	915083	915136	915189	915241	915294	915347	53
823	915399	915453	915505	915558	915611	915664	915716	915769	915822	915875	53
824	915927	915979	916033	916085	916138	916191	916243	916296	916349	91640	53
825	916454	916507	916559	916612	916664	916717	916769	916822	916875	916927	53
826	916980	917033	917085	917138	917190	917243	917295	917348	917400	91745	53
827	917506	917558	917611	917663	917716	917768	917820	917873	917925	917978	52
828	918030	918083	918135	918188	918240	918293	918345	918397	918449	918502	52
829	918555	918607	918659	918712	918764	918816	918869	918921	918973	919026	52
830	919078	919130	919183	919235	919287	919339	919392	919444	919496	919549	52
831	919601	919653	919706	919758	919810	919862	919914	919967	920019	920071	52
832	920123	920176	920228	920279	920332	920384	920436	920489	920541	920593	52
833	920645	920697	920749	920801	920853	920906	920958	921009	921062	921114	52
834	921166	921218	921270	921322	921374	921426	921478	921530	921582	921634	52
835	921686	921738	921790	921842	921894	921946	921998	922050	922102	922154	52
836	922206	922258	922310	922362	922414	922466	922518	922569	922622	922674	52
837	922725	922777	922829	922881	922933	922985	923037	923089	923140	923192	52
838	923244	923296	923348	923399	923451	923503	923555	923607	923658	923710	52
839	923762	923814	923865	923917	923969	924021	924072	924124	924176	924228	52
840	924279	924331	924383	924434	924486	924538	924589	924641	924693	924744	52
841	924796	924848	924899	924951	925003	925054	925106	925157	925209	925761	52
842	925312	925364	925415	925467	925518	925569	925621	925673	925725	925776	52
843	925828	925879	925931	925982	926034	926085	926137	926188	926239	926291	51
844	926342	926394	926445	926497	926548	926599	926651	926702	926754	926805	51
845	926857	926908	926959	927011	927062	927114	927165	927216	927268	927319	51
846	927370	927422	927473	927524	927576	927627	927678	927729	927781	927832	51
847	927883	927935	927986	928037	928088	928139	928191	928242	928293	928345	51
848	928396	928447	928498	928549	928601	928652	928703	928754	928805	928857	51
849	928908	928959	929009	929061	929112	929163	929215	929266	929317	929368	51

N	0	1	2	3	4	5	6	7	8	9	D
850	929419	929470	929521	929572	929623	929674	929725	929776	929827	929879	51
851	929929	929981	930032	930083	930134	930185	930236	930287	930338	930389	51
852	930439	930491	930542	930592	930643	930694	930745	930796	930847	930898	51
853	930949	930999	931051	931102	931153	931204	931254	931305	931356	931407	51
854	931458	931509	931559	931610	931661	931712	931763	931814	931865	931915	51
855	931966	932017	932068	932118	932169	932220	932271	932322	932372	932423	51
856	932474	932524	932575	932626	932677	932727	932778	932829	932879	932930	51
857	932981	933031	933082	933133	933183	933234	933285	933335	933386	933437	51
858	933487	933538	933589	933639	933689	933740	933791	933841	933892	933943	51
859	933993	934044	934094	934145	934195	934246	934296	934347	934397	934448	51
860	934498	934549	934599	934649	934700	934751	934801	934852	934902	934953	50
861	935003	935056	935104	935154	935205	935255	935306	935356	935406	935457	50
862	935507	935558	935608	935658	935709	935759	935809	935859	935910	935960	50
863	936011	936061	936111	936162	936212	936262	936313	936363	936413	936463	50
864	936514	936564	936614	936665	936715	936765	936815	936865	936916	936966	50
865	937016	937066	937117	937167	937217	937267	937317	937367	937418	937468	50
866	937518	937568	937618	937668	937718	937769	937819	937869	937919	937969	50
867	938019	938069	938119	938169	938219	938269	938319	938369	938419	938469	50
868	938519	938569	938619	938669	938719	938769	938819	938869	938919	938969	50
869	939019	939069	939119	939169	939219	939269	939319	939369	939419	939469	50
870	939519	939569	939619	939669	939719	939769	939819	939869	939918	939968	50
871	940018	940068	940118	940168	940218	940267	940317	940367	940417	940467	50
872	940516	940566	940616	940666	940716	940765	940815	940865	940915	940964	50
873	941014	941064	941114	941163	941213	941263	941313	941362	941412	941462	50
874	941511	941561	941611	941660	941710	941759	941809	941859	941909	941958	50
875	942008	942058	942107	942157	942207	942256	942306	942355	942405	942455	50
876	942504	942554	942603	942653	942702	942752	942801	942851	942901	942950	50
877	942999	943049	943099	943148	943198	943247	943297	943346	943396	943445	49
878	943495	943544	943594	943643	943692	943742	943791	943841	943890	943939	49
879	943989	944038	944088	944137	944186	944236	944285	944335	944384	944433	49
880	944483	944532	944581	944631	944680	944729	944779	944828	944877	944927	49
881	944976	945025	945074	945124	945173	945222	945272	945321	945370	945419	49
882	945468	945518	945567	945616	945665	945715	945764	945813	945862	945912	49
883	945961	946009	946059	946108	946157	946207	946256	946305	946354	946403	49
884	946452	946501	946551	946599	946649	946698	946747	946796	946845	946894	49
885	946943	946992	947041	947090	947139	947189	947238	947287	947336	947385	49
886	947434	947483	947532	947581	947629	947679	947728	947777	947826	947875	49
887	947924	947973	948022	948070	948119	948168	948217	948266	948315	948364	49
888	948413	948462	948511	948559	948609	948657	948706	948755	948804	948853	49
889	948902	948951	948999	949048	949097	949146	949195	949244	949292	949341	49
890	949390	949439	949488	949536	949585	949633	949683	949731	949780	949829	49
891	949878	949926	949975	950024	950073	950121	950170	950219	950267	950316	49
892	950365	950414	950462	950511	950559	950608	950657	950706	950754	950803	49
893	950851	950900	950949	950997	951046	951095	951143	951192	951240	951289	49
894	951338	951386	951435	951483	951532	951580	951629	951677	951729	951775	49
895	951823	951872	951920	951969	952017	952066	952114	952163	952211	952259	49
896	952308	952356	952405	952453	952502	952550	952599	952647	952696	952744	48
897	952792	952841	952889	952938	952986	953034	953083	953131	953179	953228	48
898	953276	953325	953373	953421	953469	953518	953566	953615	953663	953711	48
899	953759	953808	953856	953905	953953	954001	954049	954099	954146	954194	48

N	0	1	2	3	4	5	6	7	8	9	D
900	954243	954291	954339	954387	954435	954484	954532	954580	954628	954677	48
901	954725	954773	954821	954869	954918	954966	955014	955062	955110	955158	48
902	955207	955255	955303	955351	955399	955447	955495	955543	955592	955639	48
903	955688	955736	955784	955832	955880	955928	955976	956024	956072	956120	48
904	956168	956216	956265	956313	956361	956409	956457	956505	956553	956601	48
905	956649	956697	956745	956793	956840	956888	956936	956984	957032	957080	48
906	957128	957176	957224	957272	957319	957368	957416	957464	957512	957559	48
907	957607	957655	957703	957751	957799	957847	957894	957942	957990	958038	48
908	958086	958134	958181	958229	958277	958325	958373	958421	958468	958516	48
909	958564	958612	958659	958707	958755	958803	958850	958898	958946	958994	48
910	959041	959089	959137	959185	959232	959279	959328	959375	959423	959471	48
911	959518	959566	959614	959661	959709	959757	959804	959852	959899	959947	48
912	959995	960042	960090	960138	960185	960233	960280	960328	960376	960423	48
913	960471	960518	960566	960613	960661	960709	960756	960804	960851	960899	48
914	960946	960994	961041	961089	961136	961184	961231	961279	961326	961374	47
915	961421	961469	961516	961563	961611	961658	961706	961753	961801	961848	47
916	961895	961943	961990	962038	962085	962132	962179	962227	962275	962322	47
917	962369	962417	962464	962511	962559	962606	962653	962701	962748	962795	47
918	962842	962889	962937	962985	963032	963079	963126	973174	963221	963268	47
919	963315	963363	963410	963457	963504	963552	963599	963646	963693	963741	47
920	963788	963835	963882	963929	963977	964024	964071	964118	964165	964212	47
921	964259	964307	964354	964401	964448	964495	964542	964589	964637	964684	47
922	964731	964778	964825	964872	964919	964966	965013	965061	965108	965155	47
923	965202	965249	965296	965343	965389	965437	965484	965531	965578	965624	47
924	965672	965719	965766	965813	965859	965906	965954	966001	966048	966095	47
925	966142	966189	966239	966283	966329	966376	966423	966470	966517	966564	47
926	966611	966658	966705	966752	966799	966845	966892	966939	966986	967033	47
927	967079	967127	967173	967220	967267	967314	967361	967408	967454	967501	47
928	967548	967595	967642	967688	967735	967782	967829	967875	967922	967969	47
929	968016	968062	968109	968156	968202	968249	968296	968343	968389	968436	47
930	968483	968529	968576	968623	968669	968716	968763	968809	968856	968902	47
931	968949	968996	969043	969089	969136	969183	969229	969276	969323	969369	47
932	969416	969463	969509	969556	969602	969649	969695	969741	969789	969835	47
933	969882	969928	969975	970021	970068	970114	970161	970207	970254	970300	47
934	970347	970393	970439	970486	970533	970579	970626	970672	970719	970765	46
935	970812	970858	970904	970951	970997	971044	971090	971137	971183	971229	46
936	971276	971322	971369	971415	971461	971508	971554	971601	971647	971693	46
937	971739	971786	971832	971879	971925	971971	972018	972064	972110	972157	46
938	972203	972249	972295	972342	972388	972434	972481	972527	972573	972619	46
939	972666	972712	972758	972804	972851	972897	972943	972989	973035	973082	46
940	973128	973174	973220	973266	973313	973359	973405	973451	973497	973543	46
941	973589	973636	973682	973728	973774	973820	973866	973913	973959	974005	46
942	974050	974097	974143	974189	974235	974281	974327	974374	974419	974466	46
943	974512	974558	974604	974649	974695	974742	974788	974834	974819	974926	46
944	974972	975018	975064	975109	975156	975202	975248	975294	975339	975386	46
945	975432	975478	975524	975569	975616	975662	975707	975753	975799	975845	46
946	975891	975937	975983	976029	976075	976121	976167	976212	976258	976304	46
947	976349	976396	976442	976488	976533	976579	976625	976671	976717	976763	46
948	976808	976854	976899	976946	976992	977037	977083	977129	977175	977220	46
949	977266	977312	977358	977403	977449	977495	977541	977586	977632	977678	46

N	0	1	2	3	4	5	6	7	8	9	D
950	977724	977769	977815	977861	977906	977952	977998	978042	978089	978135	46
951	978181	978226	978272	978317	978363	978409	978454	978500	978546	978591	46
952	978637	978683	978728	978774	978819	978865	978911	978956	979002	979047	46
953	979093	979138	979184	979229	979275	979321	979366	979412	979457	979503	46
954	979548	979594	979639	979685	979730	979776	979821	979867	979912	979958	46
955	980003	980049	980094	980139	980185	980231	980276	980322	980367	980412	45
956	980458	980503	980549	980594	980639	980685	980730	980776	980821	980867	45
957	980912	980957	981003	981048	981093	981139	981184	981229	981275	981320	45
958	981366	981411	981456	981501	981547	981592	981637	981683	981728	981773	45
959	981819	981864	981909	981954	981999	982045	982090	982135	982181	982226	45
960	982271	982316	982362	982407	982452	982497	982543	982588	982633	982678	45
961	982723	982769	982814	982859	982904	982949	982994	983039	983085	983129	45
962	983175	983220	983265	983310	983356	983401	983446	983490	983536	983581	45
963	983626	983671	983716	983762	983807	983852	983897	983942	983987	984032	45
964	984077	984122	984167	984212	984257	984302	984347	984392	984437	984482	45
965	984527	984572	984617	984662	984707	984752	984797	984842	984887	984932	45
966	984977	985022	985067	985112	985157	985202	985247	985292	985337	985382	45
967	985426	985471	985516	985561	985606	985651	985696	985741	985786	985830	45
968	985875	985920	985965	986009	986055	986099	986144	986189	986234	986279	45
969	986324	986369	986413	986458	986504	986548	986593	986637	986682	986727	45
970	986772	986817	986861	986906	986951	986996	987040	987085	987129	987175	45
971	987219	987264	987309	987353	987398	987443	987488	987532	987577	987622	45
972	987666	987711	987756	987800	987845	987889	987934	987979	988024	988068	45
973	988113	988157	988202	988247	988291	988336	988381	988425	988469	988514	45
974	988559	988604	988648	988693	988737	988782	988826	988871	988916	988960	45
975	989005	989049	989094	989138	989183	989227	989272	989316	989361	989405	45
976	989449	989494	989539	989584	989628	989672	989717	989761	989806	989850	44
977	989895	989939	989983	990028	990072	990117	990161	990206	990250	990294	44
978	990339	990383	990428	990472	990516	990561	990605	990649	990694	990738	44
979	990783	990827	990871	990916	990960	991004	991049	991093	991137	991182	44
980	991226	991270	991315	991359	991403	991448	991492	991536	991580	991625	44
981	991669	991713	991758	991802	991846	991890	991935	991979	992023	992067	44
982	992111	992156	992199	992244	992288	992333	992377	992421	992465	992509	44
983	992554	992598	992642	992686	992730	992774	992819	992863	992907	992951	44
984	992995	993039	993083	993127	993172	993216	993259	993304	993348	993392	44
985	993436	993480	993524	993568	993613	993657	993701	993745	993789	993833	44
986	993877	993921	993965	994009	994053	994097	994141	994185	994229	994273	44
987	994317	994361	994405	994449	994493	994537	994581	994625	994669	994713	44
988	994756	994801	994845	994889	994933	994977	995021	995065	995108	995152	44
989	995196	995240	995284	995328	995372	995416	995459	995504	995547	995591	44
990	995635	995679	995723	995764	995811	995854	995898	995942	995986	996029	44
991	996074	996117	996161	996205	996249	996293	996337	996380	996424	996468	44
992	996512	996555	996599	996643	996687	996731	996774	996818	996862	996906	44
993	996949	996993	997037	997080	997124	997168	997212	997255	997299	997343	44
994	997386	997430	997474	997517	997561	997605	997648	997692	997736	997779	44
995	997823	997867	997910	997954	997998	998041	998085	998129	998170	998216	44
996	998259	998303	998347	998390	998434	998477	998521	998564	998608	998652	44
997	998695	998739	998783	998826	998869	998913	998956	998999	999043	999087	44
998	999133	999174	999218	999261	999305	999348	999392	999435	999479	999522	44
999	999565	999609	999652	999696	999739	999783	999826	999869	999913	999957	43

A TABLE of PROPORTIONAL PARTS,

Whereby the Intermediate *Logarithms* of all Numbers, and the Numbers of all *Logarithms*, from 10000 to 100000, may more readily be found out by the foregoiug Table of *Logarithms*.

D	1	2	3	4	5	6	7	8	9
43	4	8	12	17	21	25	30	34	38
44	4	8	13	17	22	26	30	35	39
45	4	9	13	18	22	27	31	36	40
46	4	9	13	18	23	27	32	36	41
47	4	9	14	18	23	28	32	37	42
48	4	9	14	19	24	28	33	38	43
49	4	9	14	19	24	29	34	39	44
50	5	10	15	20	25	30	35	40	45
51	5	10	15	20	25	30	35	40	45
52	5	10	15	20	26	31	36	41	46
53	5	10	15	21	26	31	37	42	47
54	5	10	16	21	27	32	37	43	48
55	5	11	16	22	27	33	38	44	49
56	5	11	16	22	28	33	39	44	50
57	5	11	17	22	28	34	39	45	51
58	5	11	17	23	29	34	40	46	52
59	5	11	17	23	29	35	41	47	53
60	6	12	18	24	30	36	42	48	54
61	6	12	18	24	30	36	42	48	54
62	6	12	18	24	31	37	43	49	55
63	6	12	18	25	31	37	44	50	56
64	6	12	19	25	32	38	44	51	57
65	6	13	19	26	32	39	45	52	58
66	6	13	19	26	33	39	46	52	59
67	6	13	20	26	33	40	46	53	60
68	6	13	20	27	34	40	47	54	61
69	6	13	20	27	34	41	48	55	62
70	7	14	21	28	35	42	49	56	63
71	7	14	21	28	35	42	49	56	63
72	7	14	21	28	36	43	50	57	64
73	7	14	21	29	36	43	51	58	65
74	7	14	22	29	37	44	51	59	66
75	7	15	22	30	37	45	52	60	67
76	7	15	22	30	38	45	53	60	68
77	7	15	23	30	38	46	53	61	69
78	7	15	23	31	39	46	54	62	70
79	7	15	23	31	39	47	55	63	71
80	8	16	24	32	40	48	56	64	72
81	8	16	24	32	40	48	56	64	72
82	8	16	24	32	41	49	57	65	73
83	8	16	24	33	41	49	58	66	74
84	8	16	25	33	42	50	58	67	75
85	8	17	25	34	42	51	59	68	76
86	8	17	25	34	43	51	60	68	77
87	8	17	26	34	43	52	60	69	78
88	8	17	26	35	44	52	61	70	79
89	8	17	26	35	44	53	62	71	80
90	9	18	27	36	45	54	63	72	81
91	9	18	27	36	45	54	63	72	81
92	9	18	27	36	46	55	64	73	82
93	9	18	27	37	46	55	65	74	83
94	9	18	28	37	47	56	65	75	84
95	9	19	28	38	47	57	66	76	85
96	9	19	28	38	48	57	67	76	86
97	9	19	29	38	48	58	67	77	87
98	9	19	29	39	49	58	68	78	88
99	9	19	29	39	49	59	69	79	89
100	10	20	30	40	50	60	70	80	90
101	10	20	30	40	50	60	70	80	90
102	10	20	30	40	51	61	71	81	91

D	1	2	3	4	5	6	7	8	9
103	10	20	30	41	51	61	72	82	92
104	10	20	31	41	52	62	72	83	93
105	10	21	31	42	52	63	73	84	94
106	10	21	31	42	53	63	74	84	95
107	10	21	32	42	53	64	74	85	96
108	10	21	32	43	54	64	75	86	97
109	10	21	32	43	54	65	76	87	98
110	11	22	33	44	55	66	77	88	99
111	11	22	33	44	55	66	77	88	99
112	11	22	33	44	56	67	78	89	100
113	11	22	33	45	57	67	78	90	101
114	11	22	34	45	57	68	79	91	102
115	11	23	34	46	57	69	80	92	103
116	11	23	34	46	58	69	81	92	104
117	11	23	35	46	58	70	81	93	105
118	11	23	35	47	59	70	82	94	106
119	11	23	35	47	59	71	83	95	107
120	12	24	36	48	60	72	84	96	108
121	12	24	36	48	60	72	84	96	108
122	12	24	36	48	61	73	85	97	109
123	12	24	36	48	61	73	86	98	110
124	12	24	37	49	62	74	86	99	111
125	12	25	37	50	62	75	87	100	112
126	12	25	37	50	63	75	88	100	113
127	12	25	38	50	63	76	88	101	114
128	12	25	38	51	64	76	89	102	115
129	12	25	38	51	64	77	90	103	116
130	13	26	39	52	65	78	91	104	117
131	13	26	39	52	65	78	91	104	117
132	13	26	39	52	66	79	92	105	118
133	13	26	39	53	66	79	93	106	119
134	13	26	40	53	67	80	93	107	120
135	13	27	40	54	67	81	94	108	121
136	13	27	40	54	68	81	95	108	122
137	13	27	41	54	68	82	95	109	123
138	13	27	41	55	69	82	96	110	124
139	13	27	41	55	69	83	97	111	125
140	14	28	42	56	70	84	98	112	126
141	14	28	42	56	70	84	98	112	126
142	14	28	42	56	71	85	99	113	427
143	14	28	42	57	71	85	100	114	128
144	14	28	43	57	72	86	100	115	129
145	14	28	43	58	72	87	101	116	130
146	14	29	43	58	73	87	102	116	131
147	14	29	44	58	73	88	102	117	132
148	14	29	44	59	74	88	103	118	133
149	14	29	44	59	74	89	104	119	134
150	15	30	45	60	75	90	105	120	135
151	15	30	45	60	75	90	105	120	135
152	15	30	45	60	76	91	106	121	136
153	15	30	45	60	76	91	107	122	137
154	15	30	46	61	77	92	107	123	138
155	15	31	46	62	77	93	108	124	139
156	15	31	46	62	78	93	109	124	140
157	15	31	47	62	78	94	109	125	141
158	15	31	47	63	79	94	110	126	142
159	15	31	47	63	79	95	111	127	143
160	16	32	48	64	80	96	112	128	144
161	16	32	48	64	80	96	112	128	144
162	16	32	48	64	81	97	113	129	145

D	1	2	3	4	5	6	7	8	9
163	16	32	48	65	82	98	114	130	146
164	16	32	49	66	82	98	114	131	147
165	16	33	49	66	82	99	115	132	148
166	16	33	49	66	83	99	116	132	149
167	16	33	50	66	83	100	116	133	150
168	16	33	50	67	84	100	117	134	151
169	16	33	50	67	84	101	118	135	152
170	17	34	51	68	85	102	119	136	153
171	17	34	51	68	85	102	119	136	153
172	17	34	51	68	86	103	120	137	154
173	17	34	51	69	86	103	121	138	155
174	17	34	52	69	87	104	121	139	156
175	17	34	52	70	87	105	122	140	157
176	17	35	52	70	88	105	123	140	158
177	17	35	53	70	88	106	123	141	159
178	17	35	53	71	89	106	124	142	160
179	17	35	53	71	89	107	125	143	161
180	18	36	54	72	90	108	126	144	162
181	18	36	54	72	90	108	126	144	162
182	18	36	54	72	91	109	127	145	163
183	18	36	54	73	91	109	128	146	164
184	18	36	55	73	92	110	128	147	165
185	18	37	55	74	92	111	129	148	166
186	18	37	55	74	93	111	130	148	167
187	18	37	56	74	93	112	130	149	168
188	18	37	56	75	94	112	131	150	169
189	18	37	56	75	94	113	132	151	170
190	19	38	57	76	95	114	133	152	171
191	19	38	57	76	95	114	133	152	171
192	19	38	57	76	96	115	134	153	172
193	19	38	57	77	96	115	135	154	173
194	19	38	58	77	97	116	135	155	174
195	19	39	58	78	97	117	136	156	175
196	19	39	59	78	98	117	136	156	176
197	19	39	59	78	98	118	137	157	177
198	19	39	59	79	99	118	138	158	178
199	19	39	59	79	99	119	139	159	179
200	20	40	60	80	100	120	140	160	180
201	20	40	60	80	100	120	140	160	180
202	20	40	60	80	101	121	141	161	181
203	20	40	60	81	101	121	142	162	182
204	20	40	61	81	102	122	142	163	183
205	20	41	61	82	102	123	143	164	184
206	20	41	61	82	103	123	144	164	185
207	20	41	62	82	103	124	144	165	186
208	20	41	62	83	104	124	145	166	187
209	20	41	62	83	104	125	146	167	188
210	21	42	63	84	105	126	147	168	189
211	21	42	63	84	105	126	147	168	189
212	21	42	63	84	106	127	148	169	190
213	21	42	63	85	106	127	149	170	191
214	21	42	64	85	107	128	149	171	192
215	21	43	64	86	107	129	150	172	193
216	21	43	64	86	108	129	151	172	194
217	21	43	65	86	108	130	151	173	195
218	21	43	65	87	109	130	152	174	196
219	21	43	65	87	109	131	153	175	197
220	22	44	66	88	110	132	154	176	198
221	22	44	66	88	110	132	154	176	198
222	22	44	66	88	111	133	155	177	199
223	22	44	66	89	111	133	156	178	200
224	22	44	67	89	112	134	156	179	201
225	22	45	67	90	112	135	157	180	202
226	22	45	67	90	113	135	158	180	203
227	22	45	68	90	113	136	158	181	204
228	22	45	68	91	114	136	159	182	205
229	22	45	68	91	114	137	160	183	206
230	23	46	69	92	115	138	161	184	207
231	23	46	69	92	115	138	161	184	207

D	1	2	3	4	5	6	7	8	9
232	23	46	69	92	116	139	162	185	208
233	23	46	69	93	116	139	163	186	209
234	23	46	70	93	117	140	163	187	210
235	23	47	70	94	117	141	164	188	211
236	23	47	70	94	118	141	165	188	212
237	23	47	71	94	118	142	165	189	213
238	23	47	71	95	119	142	166	190	214
239	23	47	71	95	119	143	167	191	215
240	24	48	72	96	120	144	168	192	216
241	24	48	72	96	120	144	168	192	216
242	24	48	72	96	121	145	169	193	217
243	24	48	72	97	121	145	170	194	218
244	24	48	73	97	122	146	170	195	219
245	24	49	73	98	122	147	171	196	220
246	24	49	73	98	123	147	172	196	221
247	24	49	74	98	123	148	172	197	222
248	24	49	74	99	124	148	173	198	223
249	24	49	74	99	124	149	174	199	224
250	25	50	75	100	125	150	175	200	225
251	25	50	75	100	125	150	175	200	225
252	25	50	75	100	126	151	176	201	226
253	25	50	75	101	126	151	177	202	227
254	25	50	76	101	127	152	177	203	228
255	25	50	76	102	127	153	178	204	229
256	25	51	76	102	128	153	179	204	230
257	25	51	77	102	128	154	179	205	231
258	25	51	77	103	129	154	180	206	232
259	25	51	77	103	129	155	181	207	233
260	26	52	78	104	130	156	182	208	234
261	26	52	78	104	130	156	182	208	234
262	26	52	78	104	131	156	183	209	235
263	26	52	78	105	131	157	184	210	236
264	26	52	79	105	132	158	184	211	237
265	26	53	79	106	132	159	185	212	238
266	26	53	79	106	133	159	186	212	239
267	26	53	80	106	133	160	186	213	240
268	26	53	80	107	134	160	187	214	241
269	26	53	80	107	134	161	188	215	242
270	27	54	81	108	135	162	189	216	243
271	27	54	81	108	135	162	189	216	243
272	27	54	81	108	136	163	190	217	244
273	27	54	81	109	136	163	191	218	245
274	27	54	82	109	137	164	191	219	246
275	27	55	82	110	137	165	192	220	247
276	27	55	82	110	138	165	193	220	248
277	27	55	83	110	138	166	193	221	249
278	27	55	83	111	139	166	194	222	250
279	27	55	83	111	139	167	195	223	251
280	28	56	84	112	140	168	196	224	252
281	28	56	84	112	140	168	196	224	252
282	28	56	84	112	141	169	167	225	253
283	28	56	84	113	141	169	198	226	254
284	28	56	85	113	142	170	198	227	255
285	28	57	85	114	142	171	199	228	256
286	28	57	85	114	143	171	200	228	257
287	28	57	86	114	143	172	200	229	258
288	28	57	86	115	144	172	201	230	259
289	28	57	86	115	144	173	202	231	260
290	29	58	87	116	145	174	203	232	261
291	29	58	87	116	145	174	203	232	261
292	29	58	87	116	146	175	204	233	262
293	29	58	87	117	146	175	205	234	263
294	29	58	88	117	147	176	205	235	264
295	29	59	88	118	147	177	206	236	265
296	29	59	88	118	148	177	207	236	266
297	29	59	88	118	148	178	207	237	267
298	29	59	89	119	149	178	208	238	268
299	29	59	89	119	149	179	209	239	269
300	30	60	90	120	150	180	210	240	270

The Table of Proportional Parts.

D	1	2	3	4	5	6	7	8	9
301	30	60	90	121	150	180	210	240	270
302	30	60	90	120	151	181	211	241	271
303	30	60	90	121	151	181	212	242	272
304	30	60	91	121	152	182	212	243	273
305	30	61	91	122	152	183	213	244	274
306	30	61	91	122	153	183	214	244	275
307	30	61	92	122	153	184	214	245	276
308	30	61	92	123	154	184	215	246	277
309	30	61	92	123	154	185	216	247	278
310	31	62	93	124	155	186	217	248	279
311	31	62	93	124	155	186	217	248	279
312	31	62	93	124	156	187	218	249	280
313	31	62	93	125	156	187	219	250	281
314	31	62	94	125	157	188	219	251	282
315	31	63	94	126	157	189	220	252	283
316	31	63	94	126	158	189	221	252	284
317	31	63	95	126	158	190	221	253	285
318	31	63	95	127	159	190	222	254	286
319	31	63	95	127	159	191	223	255	287
320	32	64	96	128	160	192	224	256	288
321	32	64	96	128	160	192	224	256	288
322	32	64	96	128	161	193	225	257	289
323	32	64	96	129	161	193	226	258	290
324	32	64	97	129	162	194	226	259	291
325	32	65	97	130	162	195	227	260	292
326	32	65	97	130	163	195	228	260	293
327	32	65	98	130	163	196	228	261	294
328	32	65	98	131	163	196	229	262	295
329	32	65	98	131	164	197	230	263	296
330	33	66	99	132	165	198	231	264	297
331	33	66	99	132	165	198	231	264	297
332	33	66	99	132	166	199	232	265	298
333	33	66	99	133	166	199	233	266	299
334	33	66	100	133	167	200	233	267	300
335	33	67	100	134	167	201	234	268	301
336	33	67	100	134	168	201	235	268	30
337	33	67	101	134	168	202	235	269	303
338	33	67	101	135	169	202	236	270	304
339	33	67	101	135	169	203	237	271	305
340	34	68	102	136	170	204	238	272	306
341	34	68	102	136	170	204	238	272	306
342	34	68	102	136	171	205	239	273	307
343	34	68	102	137	171	205	240	274	308
344	34	68	103	137	172	206	240	275	309
345	34	69	103	138	172	207	241	276	310
346	34	69	103	138	173	207	242	276	311
347	34	69	104	138	173	208	242	277	312
348	34	69	104	139	174	208	243	278	313
349	34	69	104	139	174	209	244	279	314
350	34	70	105	140	175	210	245	280	315
351	35	70	105	140	175	210	245	280	315
352	35	70	105	140	176	211	246	281	316
353	35	70	105	141	176	211	247	282	317
354	35	70	106	141	177	212	247	283	318
355	35	71	106	142	177	213	248	284	319
356	35	71	106	142	178	213	249	284	320
357	35	71	107	142	178	214	249	285	321
358	35	71	107	143	179	214	250	286	322
359	35	71	107	143	179	215	251	287	323
360	36	72	108	144	180	216	252	288	324
361	36	72	108	144	180	216	252	288	324
362	36	72	108	144	181	217	253	289	325
363	36	72	108	145	181	217	254	290	326
364	36	72	109	145	182	218	254	291	327
365	36	73	109	146	182	219	255	292	328
366	36	73	109	146	182	219	256	292	329
367	36	73	110	146	183	220	256	293	330
368	36	73	110	147	184	220	257	294	331

D	1	2	3	4	5	6	7	8	9
369	36	73	110	147	184	221	258	295	332
370	37	74	111	148	185	222	259	296	333
371	37	74	111	148	185	222	259	296	333
372	37	74	111	148	186	223	260	297	334
373	37	74	111	149	186	223	261	298	335
374	37	74	112	149	187	224	261	299	336
375	37	75	112	150	187	225	262	300	337
376	37	75	112	150	188	225	263	300	338
377	37	75	113	150	188	226	263	301	339
378	37	75	113	151	189	226	264	302	340
379	37	75	113	151	189	227	265	303	341
380	38	76	114	152	190	228	266	304	342
381	38	76	114	152	190	228	266	304	342
382	38	76	114	152	191	229	267	305	343
383	38	76	114	153	191	229	268	306	344
384	38	76	115	153	192	230	268	307	345
385	38	77	115	154	192	231	269	308	346
386	38	77	115	154	193	231	270	308	347
387	38	77	116	154	193	232	270	309	348
388	38	77	116	155	194	232	271	310	349
389	38	77	116	155	194	233	272	311	350
390	39	78	117	156	195	233	273	312	351
391	39	78	117	156	195	233	273	312	351
392	39	78	117	156	196	234	274	313	352
393	39	78	117	157	196	235	275	314	353
394	39	78	118	157	197	236	275	315	354
395	39	79	118	158	197	237	276	316	355
396	39	79	118	158	198	237	277	316	356
397	39	79	119	158	198	238	277	317	357
398	39	79	119	159	199	238	278	318	358
399	39	79	119	159	199	239	279	319	359
400	40	80	120	160	200	240	280	320	360
401	40	80	120	160	200	240	280	320	360
402	40	80	120	160	201	241	281	321	361
403	40	80	120	161	201	241	282	322	362
404	40	80	121	161	202	242	282	323	363
405	40	81	121	162	202	243	283	324	364
406	40	81	121	162	203	243	284	324	365
407	40	81	122	162	203	244	284	325	366
408	40	81	122	163	204	144	285	326	367
409	40	81	122	163	204	245	286	327	368
410	41	82	123	164	205	246	287	328	369
411	41	82	123	164	205	246	287	328	369
412	41	82	123	164	206	247	288	329	370
413	41	82	123	165	206	247	289	330	371
414	41	82	124	165	207	248	289	331	372
415	41	83	124	166	207	249	290	332	373
416	41	83	124	166	208	249	291	332	374
417	41	83	125	166	208	250	291	333	375
418	41	83	125	167	209	250	292	334	376
419	41	83	125	167	209	251	293	335	377
420	42	84	126	168	210	252	294	336	378
421	42	84	126	168	210	252	294	336	378
422	42	84	126	168	211	253	295	337	379
423	42	84	126	169	112	253	296	338	380
424	42	84	127	169	212	254	296	339	381
425	42	85	127	170	212	255	297	340	382
426	42	85	127	170	213	255	298	340	383
427	42	85	128	170	213	256	298	341	384
428	42	85	128	171	214	256	299	342	385
429	42	85	128	171	214	257	300	343	386
430	43	86	129	172	215	258	301	344	387
431	43	86	129	172	215	258	301	344	387
432	43	86	129	172	216	259	302	345	388
433	43	86	129	173	216	259	303	346	38
434	43	86	130	173	217	260	304	347	39
435	43	87	130	174	217	261	304	348	391

The Uſe of the Table of Proportion, *for the more ready finding out of any* Logarithm, *from* 10000 *to* 100000.

WHen you have any *Logarithm* or Number above 10000, you may find it by the Differences which are in the laſt Column of the Tables: and for your more eaſie and ready performing it, this Table is framed; wherein you have the proportional Differences: So that between each of the 10000 *Logarithms* in the Table, you may eaſily know the ten Intermediate *Logarithms*, by the Proportional Part of the Difference for any of them.

Thus in the Table the *Logarithm* of 2000 is 3.301030
The next *Logarithm*, being the *Logarithm* of 2001, is 3.301247

Alter the *Characteriſticks* of theſe *Logarithms*,

So have you the *Logarithm* of 20000, 4.301030
And the *Logarithm* of 20010, 4.301247

The Difference between theſe two Numbers is 217, which for the ten Intermediate *Logarithms* muſt be divided into 10 proportional parts, which is ready done inthis Table, as follows.

D	1	2	3	4	5	6	7	8	9
217	21	43	65	86	108	130	151	173	195

So that the *Logarithm* of 20000 being 4.301030
The *Logarithm* of 20001, by adding 21, is 4.301051
The *Logarithm* of 20002, by adding 43, is 4.301073
And ſo for the reſt, to 20010.

Or, on the other ſide, Let your *Logarithm* given be 4.301051, and you deſire to know what Number anſwers to it; the next Number leſs in the Tables is 301030 which is the *Logarithm* of 20000: but this is 21 more, and the Common Difference in the Table is about 217; turn therefore to this Difference in the Table of Proportion, and there you ſhall ſee that 21 makes your Number 1 more: So that 4.301051 is the *Logarithm* of 20001.

FINIS.

A

SUMMARY

OF SUCH

PENALTIES and FORFEITURES

As are Limited and Appointed by Several

ACTS

OF

PARLIAMENT

Relating to the

CUSTOMS and *NAVIGATION.*

AS ALSO,

For the EXPORTING and IMPORTING of

PROHIBITED GOODS.

Together with

The ſeveral STATUTES whereupon they are Grounded: Being duly compared with the Statutes at large, and the Abridgment to this preſent Year, 1664.

Uſeful for

Merchants, Factors, and all Officers belonging to the Cuſtoms, Maſters of Ships, Purſers, and Boatſwains, Mariners, Wharfingers, Lightermen, and Watermen.

In what caſe both Ship and Goods are forfeited upon Importation.

LONDON,

Printed by *M. Clark*, *Anno Dom.* 1678.

A SUMMARY

OF

PENALTIES and FORFEITURES

Annexed and Applied by Several

ACTS

OF

PARLIAMENT

Relating to the

CUSTOMS and NAVIGATION

AS ALSO,

For the Exporting and Importing of

PROHIBITED GOODS

The several STATUTES whereupon they are Grounded: Being duly compared with the Statutes at large, and the Abridgment verbatim Year 1684.

Useful for

Merchants, Factors, and all Officers belonging to the Customs, Masters of Ships, Pursers, and Boatswains, Mariners, Wharfingers, Lighterage, and Watermen.

In what case Ship and Goods are forfeited upon Importation.

LONDON,

Printed by M. Clark, Anno Dom. 1678.

TO ALL
MERCHANTS and FACTORS, and COMMANDERS or MASTERS of Ships;
AND
To all other Officers and Mariners: And to all other Honeſt-minded Men whom this may Concern,

SAMUEL STURMY

Wiſheth Proſperity, Courage, and Wiſdom in all your Lawful Undertakings.

GENTLEMEN,

FOR *Your ſakes I have inſerted this following Abridgment or Summary of the Laws, and Penalties, and Forfeitures, as are limited and appointed by ſeveral Acts of Parliament, relating to the Cuſtoms and Navigation; and in what Caſes both Ship and Goods are forfeited, upon Exporting or Importation of Prohibited Goods; together with the ſeveral Statutes whereupon they are grounded, being duly compared with the Statutes at large, and the Abridgment to* 1664.

I have been provoked to annex this Summary of Cuſtom-Houſe Laws, the more out of a Principle of good will I have to you, and by knowing ſome of your defects, or want of knowledge in theſe things, by my own in times paſt, when I was a Commander my ſelf. Through igno-

rance of these Laws your Goods have been seized and lost, and Ships stopped and hindred in their Voyages, to the great loss and damage of the Merchants, and Owners, and Mariners: Whereas if all concerned had but the knowledge of what they should, they might prevent this loss and damage, and walk safely, without any detriment to themselves or Goods, by the Officers; whereas otherwise, without this knowledge, your Ignorance is the Officers Advantage, and he will make you pay for it. And as I would advise every man to follow our Saviours Counsel, Mat. xxii. 21. Render therefore unto Cæsar the things that are Cæsar's, and unto God the things which are God's: *As likewise,* Rom. xiii. 6, 7. Render therefore to all their dues, Tribute to whom Tribute is due, Custom to whom Custom, Fear to whom Fear, Honour to whom Honour: *So likewise I do advise all Officers to go on discreetly in their Business with all Men, and not hinder, let, or abuse, in word or action, any one with whom they have Business, without just cause; nor those that fall into their hands; not to take the just rigour of the Law of* England, *lest the Universal God should take the Law of Heaven upon us for our Errors and Failings: But take reasonable satisfaction. This is my advice to both Merchants and Officers, and all others concerned. I am their Well-wisher, and so remain to be,*

Pill, Septemb. 2. 1667. SAMUEL STURMY.

A SUMMARY OF SUCH PENALTIES and FORFEITURES As are Limited and Appointed by Several ACTS of PARLIAMENT Relating to the CUSTOMS and NAVIGATION:

First, ALL manner of Goods Imported into His Majesties Plantations, or exported out of His Majesties Plantations, in Forein Shipping, both Ship and Goods are forfeited. *Vide Statute of Navigation*, 12 *Caroli* 2. 18.

Secondly, All Goods that are of the growth of *Asia*, *Africa*, and *America*, Imported in Forein Shipping are forfeit, *per id. Stat.*

Thirdly, All Goods of the growth, production, and Manufacture of *Asia*, *Africa*, and *America*, shall be Imported from the place of their growth, production, or manufacture; otherwise both Ship and Goods are forfeited, *per id. Stat.*

Except the Goods of the *Spanish* Plantations may be brought from *Spain*, and the Goods of the *Portugal* Plantations may be brought from *Portugal*, and *East India* Commodities may be brought from any Port on the Southward or Eastward of *Cape Bona Speranza*, and the Commodities of the *Levant* Seas may be brought from any Port within the *Straights*; Provided that all these Goods may be Imported in *English* Shipping, otherwise both Ship and Goods are forfeited, *per id. Stat.*

Fourthly, All Goods of Forein growth, production, or manufacture, shall be Imported from the place of their growth, production, or manufacture, or from such place where they are usually first Shipp'd for Transportation only, and only in *English* Ships, or in Ships truly belonging to such place where such Goods are lawful to be Shipped; otherwise both Ship and Goods are forfeited, *per id. Stat.*

In this Case a Dutch Ship, called the Grass Mower, *laden with Salt and Brandy was seized by me, for bringing Goods from* Rochel *to a* Bristol-*Merchant; and the Ship and Goods was bought again for* 220 *l. by a Letter of Licence.*

Fifthly, All Goods carried from Port to Port (in *England*, *Ireland*, *Wales*, or *Berwick*) in Forein Shipping, whereof the Owners or Part-owners are not all *English*, as also the Master and three fourths of the Mariners, both Ship and Goods are forfeited, *per id. Stat.*

Sixthly, All Goods of the growth, production, or manufacture of any of his Majesties Plantations, shall be first landed in *England*, *Ireland*, *Wales*, or *Berwick*, before they can be transported; otherwise both Ship and Goods are forfeited. *per id. Stat.*

Seventhly,

Seventhly, All manner of Wines, except *Rheniſh*; all Spicery and Grocery, Tobacco, Pot-aſhes, Pitch, Tar, Roſin, Salt, Deal Boards, Fir Timber, or Olive Oyl, that ſhall be imported from the *Netherlands* or *Germany*, are forfeited, as alſo the Ship in which they are Imported, *Vide Stat.* 14 *Car.* 2. 11. intituled, *An Act to prevent Frauds, &c. in his Majeſties Cuſtoms.*

Eighthly, All Freſh Herrings, Freſh Cod or Haddock, Cale-fiſh or Gul-fiſh, that ſhall be imported into *England* or *Wales*, in Forein Shipping, both Ship and Goods are forfeited. *Vide Stat.* 15 *Car.* 2. 5. intituled, *An Act for encouraging of Trade.*

Goods forfeited for being Imported into England *or* Wales, *without any Penalty upon the Ship; theſe Goods being all* Engliſh *Manufactures.*

Tin and Pewter. ALL manner of Tin and Pewter Manufactures made in Forein Parts are forfeited, *Vide Stat.* 25 *Hen.* 8. 14.

Braſs. Officers may ſearch and ſeiſe Wares brought into the Realm contrary to the ſaid Act, and none ſhall withſtand the ſearch of Braſs, Tin, and Pewter, on the forfeit of five pounds, *per id. Stat.*

Several Commodities forfeited. Woollen Cloths, Woollen Caps, Ribbons, Fringes of Silk and of Thred, Laces of Silk and of Thread, Silk Twine, Embroidered Laces of Silk or Gold, Saddles, Stirrops, or any Harneſs belonging to Saddles, Spurs, Boſſes for Bridles, Andirons, Gridirons, any manner of Locks, Hammers, Pincers, Fire-tongs, Dripping-pans, Dice, Tennis-balls, Points, Purſes, Girdles, Gloves, Harneſs for Girdles, Iron, Latten, Steel, Tin, or Alchymy, or any Wrought or any Tawed Leather, any Tawed Furs, Biskin Shoos, Galloſhes, or Cork, Knives, Daggers, Wood-knives, Bodkins, Sheers for Taylors, Sciſſors, Razors, Cheſs-men, Playing Cards, Combs, Pattens, Pack-needles, any Painted Wares, Forſers, Caskets, Rings of Copper or of Latten, gilt Chafingdiſhes, Hanging Candleſticks, Caffing Balls, Sacring Bells, Rings for Curtains, Ladles, Scummers, counterfeit Baſons, Ewers, Hats, and Bruſhes, Cards for Woolt, black Iron, Thread called Iron Wire, or whited Wire, are forfeited if any ſuch be Imported into *England* or *Wales*. *Vide Stat.* 4 *Edw.* 4.

Prohibited Goods forfeited. All Iron Wire, Card-wire, or Wool-cards, that ſhall be Imported into *England* or *Wales*, are forfeited. *per Stat.* 39 *Eliz.* 14. 14 *Car.* 2. 19.

Prohibited Goods forfeited. All manner of Girdles, Harneſs for Girdles, Points, Leather, Laces, Purſes, Pouches, Pins, Gloves, Knives, Hangers, Taylors Sheers, Sciſſors, Andirons, Cobbards, Tongs, Fire-locks, Gridirons, Stock-locks, Keys, Hinges and Garnets, Spurs, painted Glaſſes, painted Papers, painted Forcers, painted Images, painted Cloaths, beaten Gold or Silver wrought in Papers for Painters, Saddles, Saddle-trees, Horſe-Harneſs, Boots, Bits, Stirrops, Chains, Buckles, Latten Nails with Iron Shanks, Curvets, Hanging-candleſticks, Holy-water, Stops, Chafing-diſhes, Hanging Lavers, Curtain-rings, Cards for Wool, *Roan* Cards, Sheers, Buckles for Shoos, Broaches for Spits, Belts, Hawk-bells, Tin and Leaden Spoons, Wire of Latten and Iron, Candleſticks, Grates, Horns for Lanthorns, or any of theſe, being Imported into *England*, are forfeited, or the value thereof, betwixt the King and the Proſecutor. Theſe may be ſued for in any Corporation where they are. *Vide Stat.* 1 *R.* 3. 12.

All Girdles, Harneſs for Girdles, Rapiers, Daggers, Knives, Hilts, Pummels, Lockets, Blades, Handles, Scabbards, Sheaths for Knives, Saddles, Horſe-Harneſs, Stirrops,

Stirrops, Bits, Gloves, or Points, Leather Laces, or Pins, that shall be Imported into *England* or *Wales*, shall be forfeit. 5 *Eliz.* 7. *Goods prohibited.*

All manner of Silk wrought by it self, or with any other Stuff, in any place out of the Realm, Ribbons, Laces, Girdles, Corses called Corses of Tissue, or Points, shall be forfeited, *per Stat.* 19 *Hen.* 7. 21.

All Forein Bone-lace, Cut-work, Fringe, Embroidery, Bandstrings, Buttons, or Needle work, made of Silk or Thread, or either of them, being imported into *England*, *Wales*, or *Berwick*, shall be forfeited, besides the forfeiture of one hundred pound. 14 *Car.* 2. 13. *Goods prohibited* 100 *l.*

All manner of Woollen Cloth that shall be Imported into *England*, *Ireland*, or *Wales*, from beyond the Sea, shall be forfeited. *Vide Stat.* 2 *Edw.* 3. 3. and 4 *Edw.* 4. 1.

In what Cases Goods are forfeited for undue Shipping or Landing.

ALL Goods that shall be Shipped or Landed before the Custom paid or agreed for in the Custom-house, are forfeited. *Vide Stat.* 12 *Car.* 2. 4. intituled, *The Act for the Tonnage and Poundage.* *Goods shipped or landed before Custom paid are forfeit.*

All Goods that shall be Shipped or Landed, or put into any other Vessel to be Shipped or Landed, at any unlawful time or place, are forfeit, or the value of them. 1 *Eliz.* 2. and 14 *Car.* 2. 11. *unlawful time or place lose.*

All Goods that shall be put into any Lighter, Boat, or any other Vessel, to be Shipped or Landed, without Warrant from the Custom-house, and the presence of one or more Custom-house Officer, are forfeited, as also the Lighter or other Vessel in which they are found to be Shipped or Landed. *Vide Stat.* 14 *Car.* 2. 11.

If any Master of Ship, Purser, Boatswain, or other Mariner, knowing or consenting to the discharge of Goods inward bound, without Warrant from the Custom-house, or the presence of one or more Custom-house Officer, shall forfeit the value of the said Goods so unshipped. *Vide Stat.* 14 *Car.* 2. 11. *Persons consenting to the discharge of Goods inward bound without Warrant, the penalty.*

Every Customer, Collector, and Comptroller, that doth conceal his Majesties Customs; being duly Entred, shall forfeit treble the value thereof, *per Stat.* 3 *H.* 6. 3. *Officers concealing Custom, the penalty.*

If any Goods having paid Custom at the Importation, and ought to have allowance at the Exportation; if the Merchant Ship out less in quantity than is expressed in his Certificate, shall be forfeited, or the value of them. 14 *Car.* 2. 11. *The penalty to ship out less than is expresst.*

If the said Goods be Landed again in *England*, *Wales*, or *Berwick*, except they be made known in the Custom-house, shall be forfeit, *per id. Stat.* *Landing Goods, unless made known in Custom-house, forfeited.*

If any Goods be put on board a Ship to be carried from Port to Port, without Warrant from the Custom-house, all such Goods shall be forfeit, *per id. Stat.* *Goods carried from Port to Port without Warrant forfeited.*

If the true content of Quantity and Quality be not mentioned in the Certificate, under the Customers hand in the Port where they are Shipped first to pass for another Port, all such Goods not certified or discharged before the said Certificate delivered, and the Goods viewed, shall be forfeit, *per Stat.* 3 *H.* 7. 7. *Quantity and quality must be expressed.*

Quere, Whether this Statute be in force or not?

All

Goods exported, and not diſcovered unto the Officer, forfeit double the value.

All manner of Goods, Wares, or Merchandize, that ſhall be Exported, and eſcape undiſcovered unto the Officers of the Cuſtoms, the Owner or Proprietor ſhall forfeit double the Value, according to the *Book of Rates*; Except for Coals, for which they ſhall forfeit double the Cuſtom. *Vide Stat.* 14 *Car.* 2.

England and Scotland, goods that paſs.

All Goods, Wares, and Merchandize, that ſhall paſs by Land betwixt *England* and *Scotland*, ſhall paſs by and through *Berwick* and *Carliſle*, and pay Cuſtom at one of thoſe Ports, otherwiſe be forfeited, *per Stat.* 14 *Car.* 2. 11.

In what Caſes Ship and Goods are forfeited upon Exportation of Goods.

Licence to be granted to Paſſengers to paſs beyond the Sea.

IF any Woman, or other perſon under the Age of twenty one years, except Ship-boys, Saylors, or Merchants Apprentices, or Factors, ſhall paſs over the Sea, without Licence from the King, or ſix of the Privy Council, the Ship in which ſuch Perſon ſhall ſo paſs ſhall be forfeit. *Vide Stat.* 1 *Jac.* 4.

Leather, Tallow, &c.

If any Perſon ſhall Tranſport, or Ship to be Tranſported, Leather, Tallow, or Raw Hides, to any Place beyond the Sea, all ſuch Goods ſhall be forfeit, as alſo the Ship wherein they are Exported. *Vide Stat.* 18 *Eliz.* 9.

Hoys or Plats, &c.

If any Hoy or Plat croſs the Seas beyond *Norway* Eaſtward, or *Caen* in *Normandy* Southward, they ſhall be forfeit. *Vide Stat.* 1 *Eliz.* 13. 5 *Eliz.* 5. 13 *Eliz.* 15.

Corn or Victual.

If any Corn, or other Victual, be Tranſported, exceeding the Prices mentioned in the *Act for encouraging of Trade*; or if any Wood ſhall be tranſported, they ſhall forfeit the Veſſel in which it ſhall be Exported, and alſo double the value of the Goods. *Vide Stat.* 1. 2 *Phil. & Mar.* 5. the Maſters and Mariners all their Goods, and a years Impriſonment.

Engliſh Manufactures to be exported in Engliſh Shipping.

If any Goods of the growth, production, or manufacture of *Europe* be tranſported into his Majeſties Plantations, except from *England*, and in *Engliſh* built Shipping, both Ship and Goods are forfeited. *Vide Stat.* 15 *Car.* 2. 5.

Due entry to be made in 24 ho.

If the Maſter ſhall ſuffer any Goods to be Landed before a due Entry made within twenty four hours after arrival in the ſaid Plantations, both Ship and Goods are forfeited, *per id. Stat.*

Ships for fiſhing, the time to ſet out.

If any Ship ſhall ſet out to Fiſhing, or other Veſſel ſhall ſet out for the Weſt Country or *Iſeland* Fiſhing, before the tenth day of *March* in any Year, ſuch Veſſel ſhall be forfeit. *Vide Stat.* 15 *Car.* 2. 14. intituled, *An Act for the Fiſhing Trade.*

Sheep, Wool, &c.

If any Sheep or Wooll, Wooll-fells, Wooll-flocks, Mortlings, Shortlings, Yarn made of Wooll, Fullers Earth, Fulling Clay, ſhall be Exported, all ſuch Goods are forfeit, as alſo the Ship wherein they are Exported. *Vide Stat.* 12 *Car.* 2. 32.

Silver or Gold, &c.

If any Silver or Gold be Exported without Licence, it ſhall be forfeited *Vide Stat.* 5 R. 2. 2. *& 9 Edw.* 3. 1. *&* 2 *Hen.* 4. 5. *&* 2 *Hen.* 6. 6.

None but Merchant Strangers ſhall Tranſport Wooll, Wooll-fells, Leather, and Lead beyond the Seas, upon the forfeiture of the ſaid Goods. *Vide Stat.* 27 *Ed.* 3. 3. 14 *Rich.* 2. 5.

If

If any Skin, tann'd or untan'd, of any Ox, Steer, Bull, Cow, or Calf (except Calve-skins of four pound weight apiece, or under) and Sheeps Skins dreſſed without the Wooll of ſuch Skins or Hides, which are for the Ships neceſſary Proviſion, ſhall paſs out of *England* beyond the Seas, or into *Ireland* or *Scotland*, or the Iſlands belonging to *England*, ſhall be forfeited. *Vide Stat.* 14 *Car.* 2. 7. *Skins tann'd or untann'd.*

If any of the Hides or Skins aforeſaid, that ſhall be taken off of any Beaſt in any of the Iſlands belonging to *England*, except *Ireland*, ſhall be tranſported into any Place except *England*, the Offender ſhall forfeit double the value for every Offence, *per id. Stat.* *Hides tranſported, except from* Ireland, *the penalty.*

All manner of Ammunition may be prohibited at his Majeſties pleaſure. 12 *Car.* 2. 4. *Ammunition may be prohibited.*

If any Sheep ſhall be Exported, the Offender ſhall forfeit 20 *s.* for every Sheep. *Vide* 12 *Car.* 2. 32. *Sheep exported, the penalty.*

If any Wooll, Wool Fells, Wooll-flocks, Mortlings, Shorlings, Yarn made of Wooll, Fullers Earth, Fulling Clay, ſhall be ſhipped to be Exported, the Offender ſhall forfeit three ſhillings for every pound weight. *Fullers Earth, & Fulling clay.*

If any Maſter of a Ship, or other Mariner, be knowing and conſenting to the Exportation of the Goods aforeſaid, he ſhall forfeit all his Goods and Chattels, *per id. Stat.* *The penalty of giving conſent to the ſhipping of the ſaid Goods.*

Theſe Offences are alſo made Felony *per Stat.* 13, 14 *Car.* 2. 18. except ſuch Weather-ſheep, Wooll, or Wooll-flocks, as are for neceſſary proportion for the Ships uſe. *Felony to export Sheep.*

If any Wooll, Wooll-flocks, or Yarn made of Wooll, ſhall be preſſed with any Engine into any Sack, Pack, or other Wrapper, or ſhall put, preſs, or ſteeve Wooll or Woolen Yarn into any Pipe, But, or Hogſhead, Cheſt, or other Cask or Veſſel, or carry or lay any ſuch Wooll, Wooll-flocks, or Yarn made of Wool, near to the Sea, or any Navigable River, all ſuch Wooll, Wooll-flocks, and Yarn made of Wooll, ſhall be forfeited. *Vide Stat.* 13, & 14 *Car.* 2. 18. *Wooll, &c. preſt with any Engine, &c. penalty.*

If any Wooll, Wooll-fells, Mortlings, Shorlings, Yarn made of Wooll, Wooll-flocks, Fullers-Earth, Fulling-clay, or Tobaccopipe-clay, being in any Pack, Sack, Bag, or Cask, ſhall be carried upon any Horſe, Cart, or other Carriage, except in the day time, *viz.* from the firſt of *March* to the twenty ninth of *September* betwixt the Hours of four in the morning and eight at night, and from the twenty ninth of *September* until the firſt of *March* between the Hours of ſeven in the morning and five at night, otherwiſe to be forfeited, *per id. Stat.* *Fullers Earth, &c. Tobacco-pipe clay.*

If any Tobaccopipe-clay be Exported beyond the Sea, the Officer ſhall forfeit three ſhillings for every pound weight, *per id. Stat.* *Tobacco-pipe clay.*

If any manner of Sheep-skins, Wool-fells, Mortlings, Shorlings, or the Skins of any Stag, Buck, Hind, Doe, Goat, Fawn, or Kid, or the Pelts or Skins of any of them, or the Leather made of any of them, be put on board any Veſſel to be Exported, they ſhall be forfeited, as alſo two ſhillings ſix pence for every Fell, Shorling, Mortling, Pelt, or Skin, ſo ſhipped to be Exported. *Vide Stat.* 5 *Eliz.* 22. *Sheep skins, or the Leather, &c. penalty.*

All great Cattel, except of *Scotland*, that ſhall be Imported into *England* or *Wales* betwixt the firſt of *July* and the twentieth of *September* in any year; and all great Cattel of *Scotland* that ſhall be brought in betwixt the twenty fourth of *Auguſt* and the twentieth of *December* in any year, ſhall forfeit for every Head forty ſhillings; *Great Cattel imported, the penalty.*

and for every Sheep brought in betwixt the one and twentieth of *Auguſt* and twentieth of *December*, ten ſhillings, *per Stat.* 15 *Car.* 2. 5.

Goods entred in another mans name. If any Goods be entred in any other mans Name than the true Owner and Proprietor, they ſhall be forfeit: And if the Officer conceal any Offence in the ſaid Act, he ſhall forfeit one hundred pounds. *Vide Stat.* 1 *Eliz.* 11.

Priſage and Butlerage of Wines. If any man, being free of the Priſage or Butlerage of Wine, ſhall Enter another mans Wines in his Name, whereby the King loſeth his Butlerage, all Wines ſo Entred are to forfeit double the value of the Cuſtoms thereof, *Vide* 1 *Hen.* 8. 5.

If any man offend contrary to the *Stat.* 1 *Hen.* 8. 5. he ſhall forfeit all his Goods. *Vide Stat.* 2, and 3 *Edw.* 6. 22.

Sugar, Tobacco, Ginger. If any Officer of the Cuſtom ſhall ſuffer or give any Warrant for any Sugar, Tobacco, Ginger, Cotton-wooll, Indico, Speckle-wood, *Jamaica*-wood, Fuſtick, or any other Dying-Wood, of the growth of any of his Majeſties Plantations, to be conveyed into any Parts beyond the Seas, before they are Landed in *England* or *Wales*, for every Offence he ſhall forfeit the value of the ſaid Goods. *Vide Stat.* 15 *Car.* 2. 5.

Goods of Alien Merchants. All the Goods of an Alien Merchant or Factor in any of his Majeſties Plantations are forfeited. *Vide Stat.* 12 *Car.* 2. 18.

Copper, Braſs, Bell-metal, &c. If any manner of Copper, Braſs, Latten, Bell-metal, Pan-metal, Gun-metal, or Shroof-metal, ſhall be put on board any Veſſel to be tranſported, the Offender ſhall forfeit double the value, to be divided betwixt the King and the Proſecutor. *Vide Stat.* 33 *Hen.* 8. 7.

10 l. penalty. And alſo ten pounds more for every thouſand pound weight, *per Stat.* 2 *&* 3 *Edw.* 6. 37.

The Cuſtomer not performing duty, the penalty. The Cuſtomer ſhall take Bond in double the value of the ſaid Goods, when they ſhall be tranſported from Port to Port, and alſo 10 *l.* over and above for every thouſand pounds weight, and give Bond; which Bond, if it want a Date, the Cuſtomer ſhall forfeit the value of the ſaid Goods, and alſo his Place, *per id. Stat.*

To grant a falſe Certificate, the penalty. If any Cuſtomer grant a falſe Certificate for the ſaid Goods, he ſhall forfeit his Place, and the value of the Goods ſo concealed. 33 *Hen.* 8. 7.

The penalty of the not diſcovering. If any Maſter of a Ship, Owner, Purſer, or Boatſwain, knowing ſuch Metals to be ſhipped, and do not diſcloſe it within three days, he ſhall forfeit double the value of it. *Vide Stat.* 2 *&* 3 *Edw.* 6. 37.

Not ſeiſing the ſaid Goods, the penalty. If any Officer of the Cuſtom-houſe, knowing ſuch Metals to be Shipped to be Tranſported, do not ſeize it, he ſhall loſe his Office, and the value of the Goods ſo Shipped. *Vide Stat.* 2 *&* 3 *Edw.* 6. 37.

The ſaid Goods not to be ſhipp'd but where there is a Cuſtomer. If any Perſon ſhip any of the ſaid Metals at any Place, except where there is a Cuſtomer, he ſhall forfeit the value of the Goods, and alſo ten pounds for every 1000 pound weight, *per id. Stat.*

Penalty 1000 *l. to a Governour not doing his duty.* If the Governour of any Plantation belonging to his Majeſty, do not his duty juſtly, according to the *Act for Encouragement of Trade*, he ſhall forfeit his Place and 1000 *l. per Stat.* 15 *Car.* 2. 15.

Tranſporting Leather. Every Perſon that ſhall be found guilty of tranſporting of Leather, ſhall for every Offence forfeit 500 *l. Vide Stat.* 14 *Car.* 2. 7.

Every

Every Customer, or other Officer, that shall neglect his duty, or connive at the Transportation of Leather, shall for every Offence forfeit 100 pounds. *Vide Stat.* 1 *Jac.* 22. *Officer neglecting his duty, penalty* 100 *l.*

Every Customer, or other Officer, that shall make a false Certificate of the Landing of Leather, shall forfeit 100 *l. per id. Stat.* *To make false Certificates of landing Leather, penalty* 100 *l.*

If any Goods or Merchandise shall be Shipped or Landed at any unlawful time or place, for every Offence the Master, Owner, or Purser shall forfeit 100 *l.* 1 *Eliz.* 11. & 14 *Car.* 2. 11. *Goods shipp'd at any unlawful hour, the penalty* 100 *l.*

Lawful times are only from the first of March *until the first of* September, *betwixt Sun-rising and Sun-Setting; and from the first of* September *until the first of* March *betwixt seven a clock in the Morning, and four a clock in the Afternoon. The Port of* Hull *is here excepted.* *What lawful times are by Order.*

If the Captain, Master of a Ship, or Purser outward bound, shall take in any Goods before Entry, he shall forfeit 100 *l. Vide Stat.* 14 *Car.* 2. 11. *Goods taken in before Entry made* 100 *l.*

If he go away before cleared on Oath in the Custom-house, giving a true Accompt of his Lading, *&c.* he shall forfeit 100 l. *per id. Stat.* *To go before cleared on Oath, penalty* 100 *l.*

If any Captain, Master of a Ship, or Purser, do not bring his Ship to the Port, and make Entry with as much speed as Wind and Water will permit, for every Offence he shall forfeit 100 *l. Vide Stat.* 14 *Car.* 2. *Master of Ship to bring his Ship with as much convenience, &c.*

If he permit any Goods to be taken out of the Ship, to be Landed, before he hath made his general Entry upon Oath in the Custom-house, for every Offence he shall forfeit 100 *l. Vide Stat.* 1 *Eliz.* 11. *To suffer Goods taken out before a general entry, penalty* 100 *l.*

If any Captain, Master of of a Ship, Purser, or Boat swain, or other Person taking Charge of the Ship, shall permit any sort of the Package therein to be opened, imbeazled, or altered, for every Offence he shall forfeit 100 *l. Vide Stat.* 14 *Car.* 2. 11. *Goods imbezelled, &c.* 100 *l.*

Men of War to be liable to the Rules that Merchants Ships are subject to. Liberty to go on board and take out Prohibited and Uncustomed Goods. The Commissioners and their Deputies to enter on board, and bring on shore Goods outward and inward bound. The Officers may stay on board until the Goods be discharged. 14 *Car.* 2.

If any Goods be found concealed aboard the Ship, when the Officers of the Customs have cleared the Ship, the Master, or other Person, shall for every Offence forfeit 100 *l. per id. Stat.* *Goods concealed,* 100 *l.*

If any Wharfinger, Crane-keeper, Searcher, Lighterman, or other Officer, knowing any Offence contrary to the Statute, do not disclose it to the Customer, he shall forfeit 100 *l. Vide Stat.* 1 *Eliz.* 11. *Wharfinger, &c. not disclosing. &c. penalty* 100 *l.*

If any Wharfinger or Crane-keeper shall take up or Land, or suffer to be Landed, or ship off, or suffer to be Water bound, any Wares or Merchandizes, at any unlawful time, or without the presence of, or notice given to an Officer at the Custom-house, he shall forfeit for every Offence 100 *l. per Stat.* 14 *Car.* 2. 11. The Port of *Hull* excepted. *To suffer Goods to be taken up or landed at unlawful times.*

100 l. penalty for taking of Bribes. If any Officers of the Customs shall directly or indirectly receive any Bribe, Recompence, or Reward, or shall connive at any false Entry of Goods, he shall forfeit 100 *l. per id. Stat.*

50 l. penalty to give a Bribe. If any Merchant, or other Person, shall give such Bribes, for every Offence he shall forfeit 50 *l. per id. Stat.*

100 l. If any Packet Boat, or other Vessel appointed to carry Letters, shall Import or Export any Goods or Merchandize, for every Offence the Master shall forfeit 100 *l. per. id. Stat.*

Forein Bone-lace, Cut-work, penalty 50 l. If any Person offer to sale any Forein Bone-lace, Cut-work, Imbroidery, Fringe, or Needle work made of Silk, or Thread, for every Offence he shall forfeit 50 *l. per id. Stat.*

100 l. If any of the said Goods be Imported into *England* or *Wales*, the Offender shall forfeit 100 *l. per id. Stat.*

False Certificate, penalty 50 l. If any Officer of any Port shall make a false Certificate, he shall forfeit 50 *l. per id. Stat.*

To falsifie any Warrant 100 l. If any Person shall falsifie any Custom-house Warrant, he shall forfeit for every Offence 100 *l. per id. Stat.*

The Officer to make a true report, on penalty of 100 l. Every Officer appointed to perfect an Entry, shall make report thereof under his Hand, unto the Chief Officers of the Customs' the next day, up on the Penalty of 100 *l.* unless there be cause of longer time to be allowed by the chief Officers of the Customs, *per id. Stat.*

French Vessels not to put Goods on shore, not paying 5 s. per Tun, the penalty 10 l. If any *French* Vessel put any Goods or Passengers on shore, or into any Boat, to be conveyed on shore, and not pay the five shillings *per* Tonnage due upon *French* Vessels, upon their return they shall forfeit ten pounds, and pay all the former Duty, *per id. Stat.*

Pilot or Waterman going out of any Port brings Goods, &c. penalty 40 l. If any Pilot or Waterman shall go out from any Port, to bring in any Goods or Passengers from aboard of any *French* Vessels, for every Offence he shall forfeit 40 *l. per id. Stat.*

Officers not giving attendance, penalty 100 l. If any Customer, Comptroller, or Searcher, or their Deputies, do not give their attendance at the Custom-house at such time and places as are appointed by Law, and also do not their utmost diligence in their respective Places, for every Offence the Offender shall forfeit 100 *l. Vide Stat.* 1 *Eliz.* 11.

Not resident on his Place, penalty 100 l. If any Customer, Comptroller, or Searcher be not resident upon his Place and Office, for every Offence he shall forfeit 10 *l. Vide Stat.* 1 *Hen.* 4. 13. 4 *Hen.* 4. 20, 21. 13 *Hen.* 4. 5.

No Custom Officer to be Owner of a Ship, or use Merchandize, &c. penalty 40 l. If any Custom-house Officer fraight any Ship, or use any Merchandize, or keep any Wharf, or hold any Hostery, or Tavern, or be Factor, or Attorney, or Host to any Merchant, for every Offence he shall forfeit 40 *l.* for every six Months, to be divided betwixt the King and the Prosecutor. *Vide Stat.* 20 *Hen.* 6. 5.

If

If any Customer, Comptroller, or Searcher, be a Common Officer, or Deputy to a Common Officer, in a City, Burrough, or Town, upon the penalty of 40 *l.* for every six Months he shall so officiate both Offices together. *Vide Stat.* 3 *Hen.* 7. 1. *No Custom Officer to be a common Officer, penalty* 40 *l.*

Quere, Whether this Statute be in force, or Repealed by the Statute of 1 *Hen.* 8. 5.

English Shipping is either *English* built, or bought *bona fide* by *English* Money, whereof every Owner or Part-owner are *English*, *Irish*, *Welch*, or of his Majesties Plantations. *English-built shipping, what is meant.*

A TABLE

A TABLE OF THE STATUTES

Relating to the

CUSTOMS, and NAVIGATION, and TRADE,

Made in the Reign of

King *CHARLES* the Second.

Tonnage and Poundage —— 12 *Car.* II. 4.

Preventing Frauds —— 14 *Car.* II. 11.

Navigation Encouraged —— 12 *Car.* II. 18.

Wooll, Sheep, &c. —— 12 *Car.* II. 32.

Leather, &c. —— 14 *Car.* II. 7.

Bonelace, &c. —— 14 *Car.* II. 13.

Wooll-fells, &c. —— 14 *Car.* II. 18.

Card.Wire and *Iron Wire,* &c. —— 14 *Car.* II. 19.

Encouragement of Trade, &c. —— 15 *Car.* II. 5.

Encouragement of Fiſhing —— 15 *Car.* II. 14.

THE

THE AUTHOR TO His Books.

SInce now, my Book, thou art ſo far gone on,
Abroad on Gods Name, and be better known:
But had there been now but one quarter done,
That, nor the reſt, ſhould n'er have ſeen the Sun.
To Friends be free, ope them thy Treaſures Store:
But carping Scoffers, let them have no more
But Scraps; for that's enough, and good for ſuch
As poyſon all they ſee, foul all they touch,
And on Mechanick Scapes forge Arts detraction,
Ere they will wink, or mend the faultier action
Th' Errata's made. I never did intend it
For ſuch as not commend, nor can come mend it;
Not I: And ſo I end it.

A

COMPENDIUM
OF
FORTIFICATION.
BOTH
Geometrically and Inſtrumentally
BY A
SCALE,

The Making whereof is ſhewed by the Tables, and their Uſe, both of the Tables and the Scale, for ſpeedy Protracting of any Fort conſiſting of 8 Bulwarks, whoſe Baſtion-Angles ſhall not exceed 90 Degrees; and ſo the like for Baſtion-Angles of 12 Bulwarks.

WRITTEN BY

PHILIP STAYNRED

Profeſſor and Teacher of the MATHEMATICKS
in the City of BRISTOL.

JER. XVI. 19.

The Lord is my ſtrength, and my fortreſs, and my refuge in the day of affliction.

LONDON,
Printed by *M. Clark*, *Anno Dom.* 1678.

A

COMPENDIUM

OF

FORTIFICATION,

BOTH

Geometrically and Instrumentally

BY A

SCALE,

The Making whereof is shewed by the Tables, and their Use, both of the Tables and the Scale, for speedy Protracting of any Fort consisting of 5 Bulwarks, whole Bastion-Angles shall not exceed 90 Degrees; and so the like for Bastion-Angles of 12 Bulwarks.

WRITTEN BY

PHILIP STATNRED

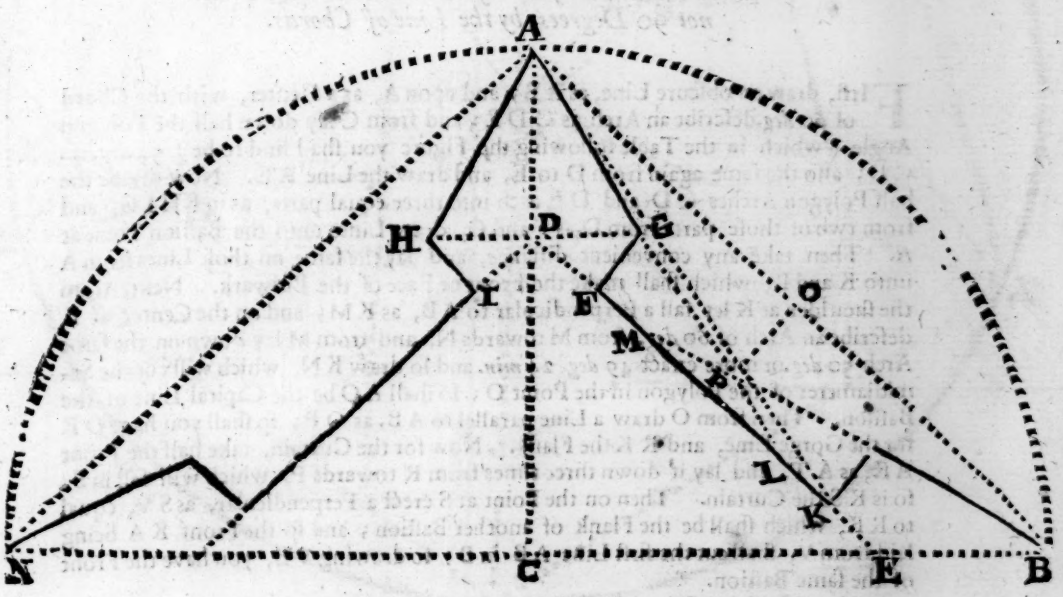
Professor and Teacher of the MATHEMATICKS in the City of BRISTOL.

LONDON:

Printed by M. Clerk, Anno Dom. 1678.

A COMPENDIUM OF FORTIFICATION.

FIrſt, I will deſcribe part of a Tetragon or ſquare Fort, and explain the names of the Sides and Angles thereof, as in the Figure following.



Names of the Sides of a Fort.

A B the Outward ſide of the Polygon, and D E the Inward ſide.
C A the Semidiameter of the Outward Polygon, and C D the Inward.
I H A G F the Bulwark or Baſtion.
A G, or A H, the Front or Face of the Baſtion ——— 280 *Foot.*
A D the Capital or Head Line.
D I, or D F, the Gorge Line.
I H, or F G, the Flank, and F M the ſecond Flank.
D G the Eſpaule, or Shoulder.
F K the Curtain ——— 420 *Foot.*
A K the longeſt Line of Defence ——— 720 *Foot.*
A L the ſhorteſt Line of Defence.

Names of the Angles.

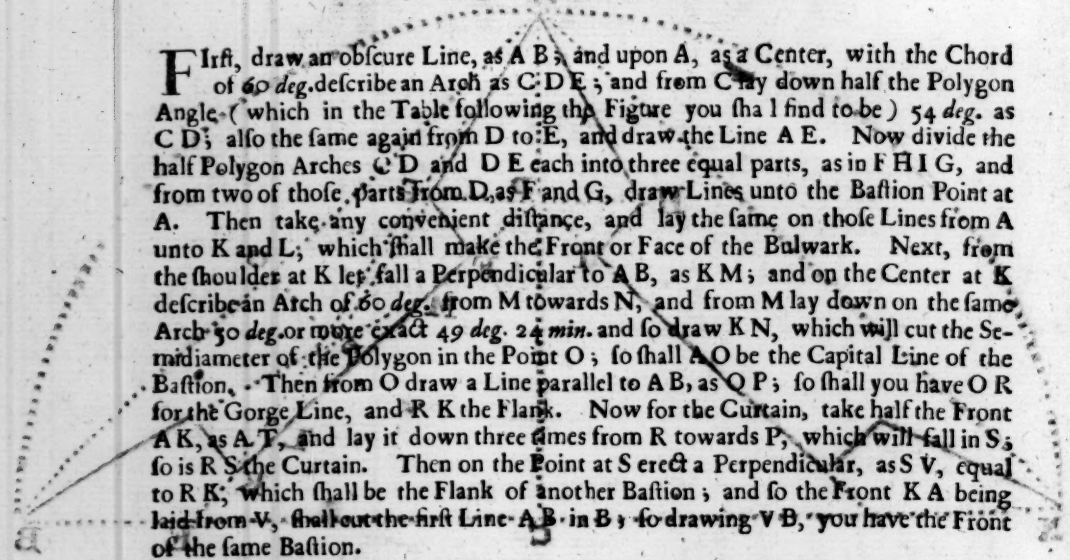
N A B the Angle of the Polygon, and N A C the half Angle.
H A G the Flanked Angle of the Bulwark.

A G F the Angle of the Shoulder.
F D G the Angle forming the Flank, commonly 40 Degrees.
G A O the Inward Flanking Angle.
A P B the Outward Flanking Angle, and A P O half the ſame.

Note, That the Baſtion or Flanked Angle H A G muſt never be leſs than 60 Degrees, neither above 90 Degrees; but as near as you can to an Angle of 90 Degrees: So that it may be defended from the Flank and Curtain on either ſide.

The longeſt Line of Defence K A not to be above 12 ſcore Yards, that is, 720 Foot, being within Musket-ſhot, and the breadth of the Rampier to reſiſt the Battery 100 Foot.

To deſcribe a Fort of Five Bulwarks, or any other; ſo that the Baſtion, or Flanked Angle of 8 Baſtions or Bulwarks exceed not 90 Degrees, by the Line of Chords.

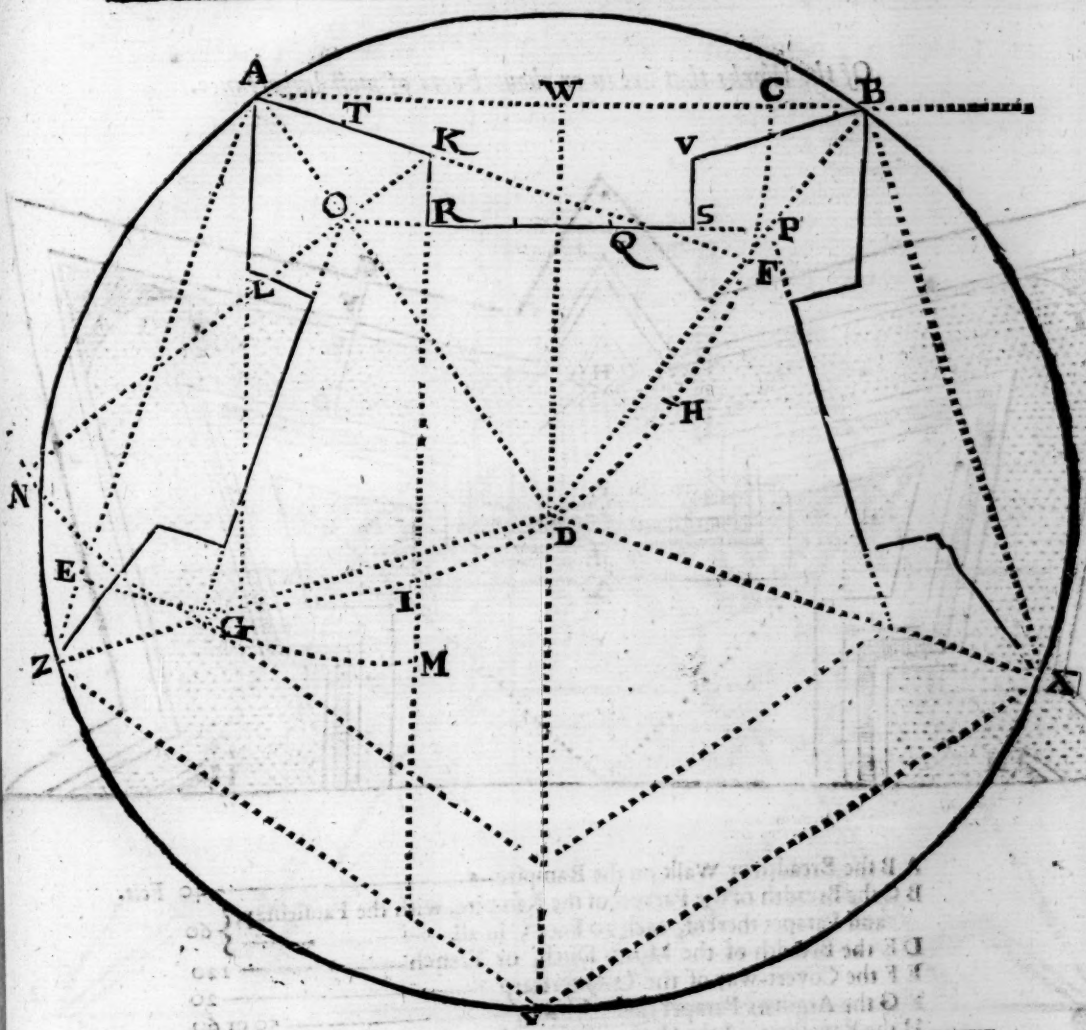


FIrſt, draw an obſcure Line, as A B; and upon A, as a Center, with the Chord of 60 *deg.* deſcribe an Arch as C D E; and from C lay down half the Polygon Angle (which in the Table following the Figure you ſhall find to be) 54 *deg.* as C D; alſo the ſame again from D to E, and draw the Line A E. Now divide the half Polygon Arches C D and D E each into three equal parts, as in F H I G, and from two of thoſe parts from D, as F and G, draw Lines unto the Baſtion Point at A. Then take any convenient diſtance, and lay the ſame on thoſe Lines from A unto K and L; which ſhall make the Front or Face of the Bulwark. Next, from the ſhoulder at K let fall a Perpendicular to A B, as K M; and on the Center at K deſcribe an Arch of 60 *deg.* from M towards N, and from M lay down on the ſame Arch 50 *deg.* or more exact 49 *deg.* 24 *min.* and ſo draw K N, which will cut the Semidiameter of the Polygon in the Point O; ſo ſhall A O be the Capital Line of the Baſtion. Then from O draw a Line parallel to A B, as Q P; ſo ſhall you have O R for the Gorge Line, and R K the Flank. Now for the Curtain, take half the Front A K, as A T, and lay it down three times from R towards P, which will fall in S; ſo is R S the Curtain. Then on the Point at S erect a Perpendicular, as S V, equal to R K, which ſhall be the Flank of another Baſtion; and ſo the Front K A being laid from V, ſhall cut the firſt Line A B in B; ſo drawing V B, you have the Front of the ſame Baſtion.

Laſtly, Divide A B in the Middle, as in W, and from W raiſe a Perpendicular to A B, which will cut the Semidiameter of the Polygon in the Point D; ſo is D the Center of the Polygon. And with the ſame Semidiameter D A you muſt deſcribe a Circle, of the which A B is the $\frac{1}{5}$ part, which diſtance will reach from B unto X, and from X unto Y, and ſo to Z, and ſo to your firſt Point at A, where you begun your Work.

For the other Baſtions, they may be eaſily tranſported from the firſt Baſtion. And note, That if your Fort exceed 8 Bulwarks, you muſt add 15 *deg.* to half the Polygon Angle, ſo have you the Baſtion Angle, and then work as before. But in the Forts that exceed not 8 Bulwarks, where the Baſtion Angle will not be above 90 *d.* you muſt take the $\frac{2}{3}$ part of the Angle of the Polygon.

The longeſt Line of Defence is from A unto Q, and ſhould not exceed 720 Foot (becauſe not being within Musket-ſhot) the Curtain R S about 420 Foot, and the Front A K 280 Foot: And for the Flank R K, and Gorge R O, their proportion commonly is as 6 to 7: But the Angle K O R forming the Flank is about 40 *gr.* by which the Proportion is near as 5 to 6.



A Table for 8 Bastions.

Polygons.	½ *Angle of the Polygons.*	½ *Angle of the Bastions.*
	Degrees.	*Degrees.*
4 Tetragon	45	30
5 Pentagon	54	36
6 Hexagon	60	40
7 Heptagon	64 2/7	42 6/7
8 Octagon	67 ½	45

The ½ Bastion Angle is here found by taking the ⅔ of the ½ Polygon Angle: So the Bastion Angle will be an Angle of 90 *deg.* in the *Octagon*. And no more must the Bastion Angle be in any Polygon.

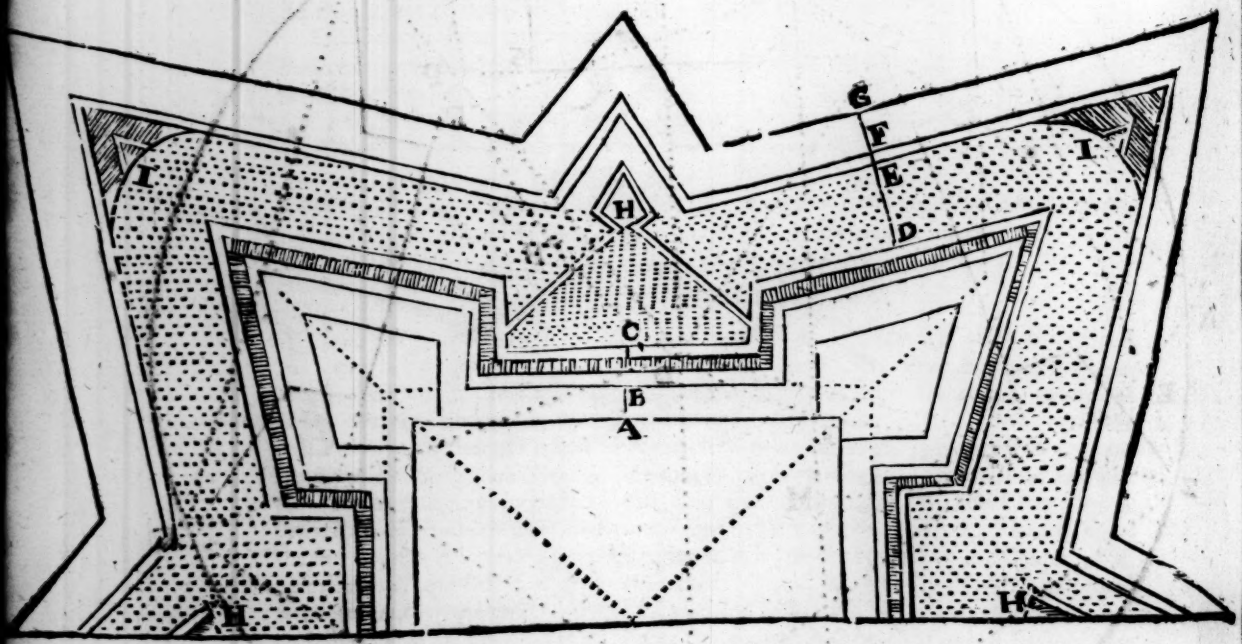
A Table for 12 Bastions.

Polygons.	½ *Angle of the Polygon.*	½ *Angle of the Bastion.*
	Degrees.	*Degrees.*
4 Tetragon	45	30
5 Pentagon	54	34 ½
6 Hexagon	60	37 ½
7 Heptag.	64 2/7	39 2/14
8 Octagon	67 ½	41 ¼
9 Enneag.	70	42 ½
10 Decagon	72	43 ½
11 Undecag.	73 7/12	44 7/12
12 Dodecag.	75	45

The ½ Bastion Angle is here found by adding 15 *d.* to ½ the Polygon Angle, and take the ½ thereof: So the Bastion Angle will be an Angle of 90 *deg.* in a *Dodecagon*.

Of

Of the Works that are in or about Forts of moſt Importance.

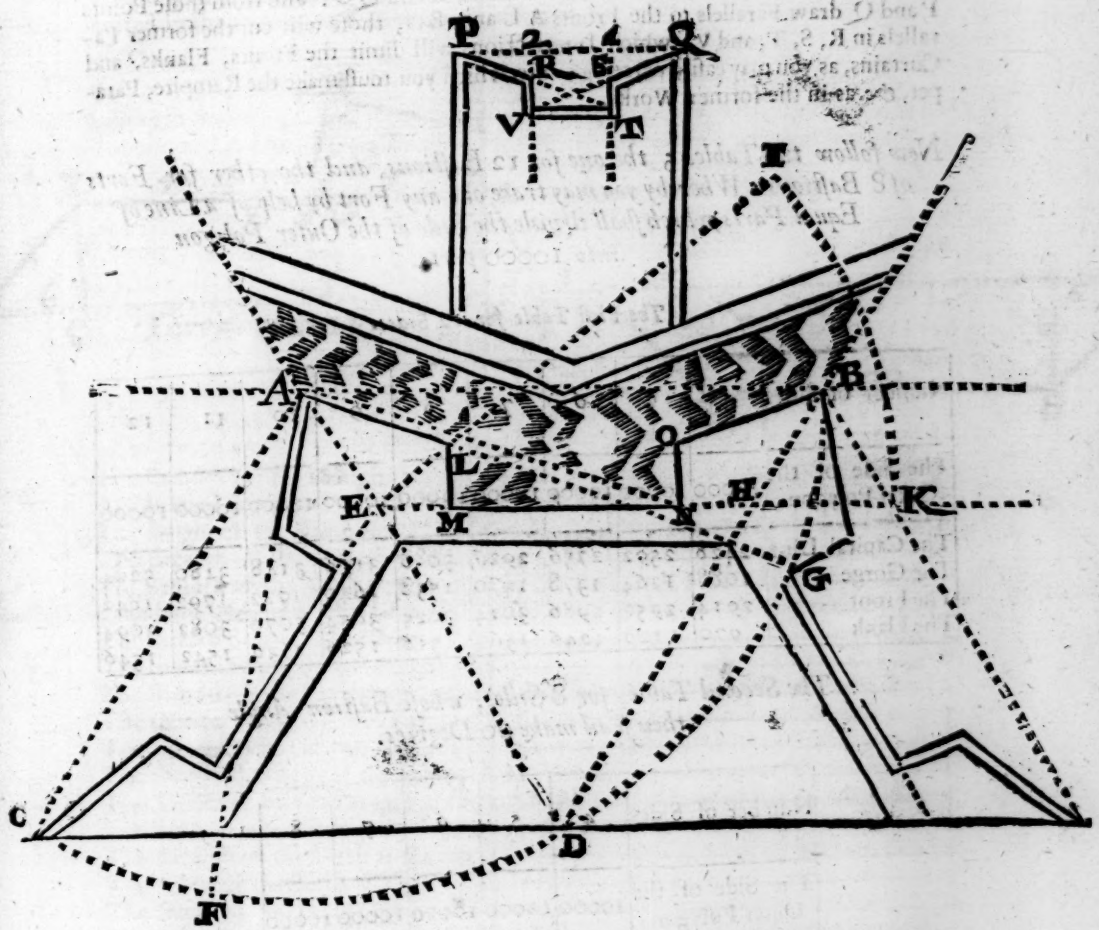


A B the Breadth or Walk on the Rampire ——— 40 *Feet.*
B C the Breadth of the Parapet of the Rampire, with the Fauſſebray, and Parapet thereof, each 20 Foot; in all ——— 60
D E the Breadth of the Moat, Ditch, or Trench ——— 120
E F the Covert-way of the Counterſcarp ——— 20
F G the Argin or Parapet thereof, being ——— 50 or 60
H the Ravelines; I the Half-moons, with their Parapets ——— 20

There may be ſometimes an occaſion in Forts to raiſe Mounts, Cavaliers, Platforms, or Batteries, to command all the other Works, and to view the Country about; which may be raiſed upon the Baſtions, if you have room withal to make uſe of the Flanks: Otherwiſe let them be raiſed on the Curtains, a little within the Rampire, ſo that you may have room left for the Walk.

To

To draw the Platform of a Fort, beginning with the Capital (or Head) Line; And alſo to draw the Horn-works.



LEt the Fort be an *Hexagon*, that is, of ſix Baſtions or Bulwarks. Firſt, draw the Line A B; and upon A deſcribe an Arch of a Circle, as B D C, whereon lay downhalf the Polygon-Angle, which in the former Table you ſhall find to be 60 *deg.* as from B unto D, and thence to C; and draw A C and A D. Now the $\frac{1}{3}$ part of the half Polygon Angle is B G and C F; then draw the Obſcure Line A F and A G. Next you ſhall make choice of the Capital Line, of any ſufficient length, which let be A E; and from E draw a Line parallel to A B, as E H, continued; and upon the Point E, as a Center, deſcribe K I, making it an Angle of 40 *deg.* as K E I; ſo ſhall E I cut out the Front in L, as A L: So from L let fall the Perpendicular L M, which ſhall be the Flank; and M N the Curtain ſhall be as formerly the whole length of the Front, and a half more. For the reſt of the Work, you muſt proceed as formerly.

For

For the Horn-works.

YOu muſt continue the Flankers M L and N O unto P and Q; then take the longeſt Line of Defence A N, and lay it thereon from the ſhoulders at L and O, unto P and Q; drawing the Line P Q, dividing it into three equal parts; and from thoſe parts 1 and 2, draw Parallels unto P L and Q O: alſo from thoſe Points P and Q draw Parallels to the Fronts A L and B O, thoſe will cut the former Parallels in R, S, T, and V, which Interſections will limit the Fronts, Flanks, and Curtains, as you may eaſily perceive; unto which you muſt make the Rampire, Parapet, &c. as in the former Works.

Now follow two Tables; the one for 12 *Baſtions, and the other for Forts of* 8 *Baſtions: Whereby you may trace out any Fort by help of a Line of Equal Parts, which ſhall divide the Side of the Outer Polygon into* 10000 *parts.*

The Firſt Table for 12 *Sides.*

Number of Sides	4	5	6	7	8	9	10	11	12
The Side of the Outer Polygon.	10000	10000	10000	10000	10000	10000	10000	10000	10000
The Capital Line	2428	2592	2756	2926	3086	3136	3148	3180	3204
The Gorge	1088	1264	1378	1470	1558	1640	1722	1792	1842
The Front	2914	2952	2986	3014	3024	3054	3070	3082	3094
The Flank	970	1128	1246	1360	1516	1526	1536	1542	1546

The Second Table, for 8 *Sides, whoſe Baſtion Angle then ſhall make* 90 *Degrees.*

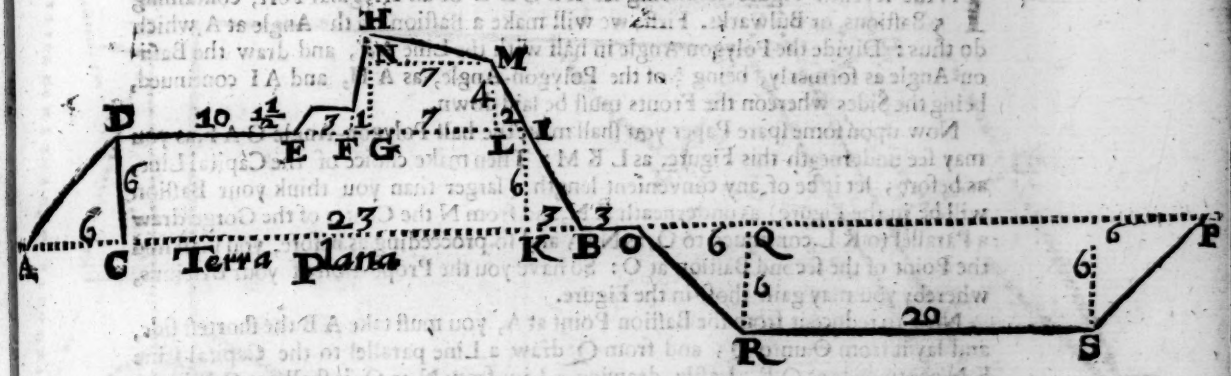
Number of Sides	4	5	6	7	8
The Side of the Outer Polygon	10000	10000	10000	10000	10000
The Capital Line	2396	2498	2602	2695	2778
The Gorge	1120	1327	1480	1599	1698
The Front	2914	2939	2959	2975	2987
The Flank	940	1113	1242	1342	1423

The Uſe of theſe Tables.

LEt it be required to draw the Proportional Dimenſion of a Regular Fort of ſix *Sides*: As for Example, in the former Figure, whoſe *Side* A B muſt be divided into 100 equal parts, and each part ſuppoſed to be ſubdivided into 10 parts: So have you 1000 parts, which ſhall ſuffice. Now proceeding according to former Directions, until you come to make choice of your Capital Line, you ſhall here find in the ſecond Table, which is beſt for the purpoſe, under the Figure *6*, and right againſt the word *Capital* in the firſt Column, 2602, but 260 will ſerve: Take the

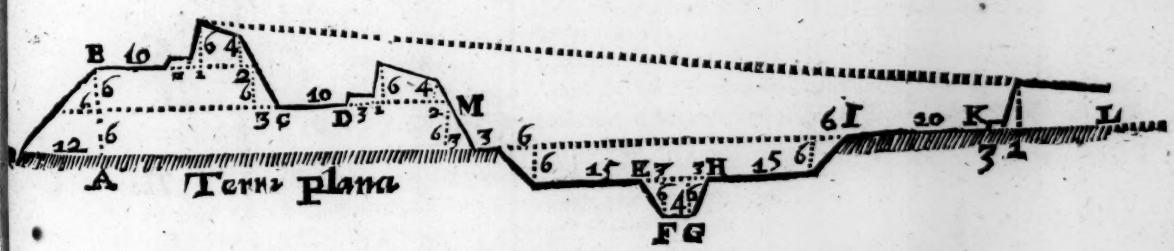
ſame

ſame from the Scale of Equal parts, and lay it from the Baſtion Point at A, and it falls in the Point E, which will be the Center of the Baſtion. From thence you may lay down the Gorge Line out of the Table, which is 148 unto M: So will the Front A L be 296, and the Flank M L. The Curtain, being once and a half the length of the Front, will be M N 444. Thus you may do for any of the reſt. Theſe Tables are uſeful for Irregular Forts; But firſt I will ſhew you the Height, Breadth, and Scarpings of the Rampire, Parapet, Ditch, &c. of theſe Sconces, as they are repreſented in the Profile, or Section, as followeth:



The Breadth of the Rampire may be 24, 30, or 40 Foot; but here A B is but	32
The Inward Scarp A C	6
The Height of the Rampire C D	6
The Breadth of the Walk of the Rampire D E	10
The Breadth of the Bank or Foot-pace of the Parapet E F	3
and the Height of the ſame Foot-pace	1½
The Inward Scarp of the Parapet F G	1
The Inward Height of the Parapet G H	6
The Breadth of the Parapet at the Foot F I	10
The Outward Scarp of the Rampire B K	3
The Inward Scarp of the Parapet I L	2
The Outward Height of the Parapet L M	4
The Thickneſs of the Parapet at the top M N	7
The Brim of the Ditch B O	3
The Breadth of the Ditch at the top O P	32
The Scarp of the Ditch O Q	6
The Depth of the Ditch Q R	6
The Breadth of the Ditch at the Bottom R S	20

The Profile or Section of a Fort with a Fauſſe-Bray and Counterſcarp; alſo Subtrenched.



C D is the Fauſſebray, and D M his Parapet: E F G H is the Subtrench, and I K the Covert-way. Laſtly, K L is the Argin or Parapet of the Counterſcarp.

Note, That the Height of the Rampire A B ought to be raiſed 15 or 18 Foot above the *Terra Plana*, although here it is but 12 Foot, which is ſomewhat too low to command the Trench or Ditch: But if the Trench be made broader, then it will command the bottom thereof.

Of Irregular Fortification.

IN the ſeventh Figure following let A B C D E be an Irregular Fort, containing 5 Baſtions, or Bulwarks. Firſt, we will make a Baſtion on the Angle at A, which do thus: Divide the Polygon Angle in half with the Line A F, and draw the Baſtion-Angle as formerly, being $\frac{2}{3}$ of the Polygon-Angle, as A H, and A I continued, being the Sides whereon the Fronts muſt be laid down.

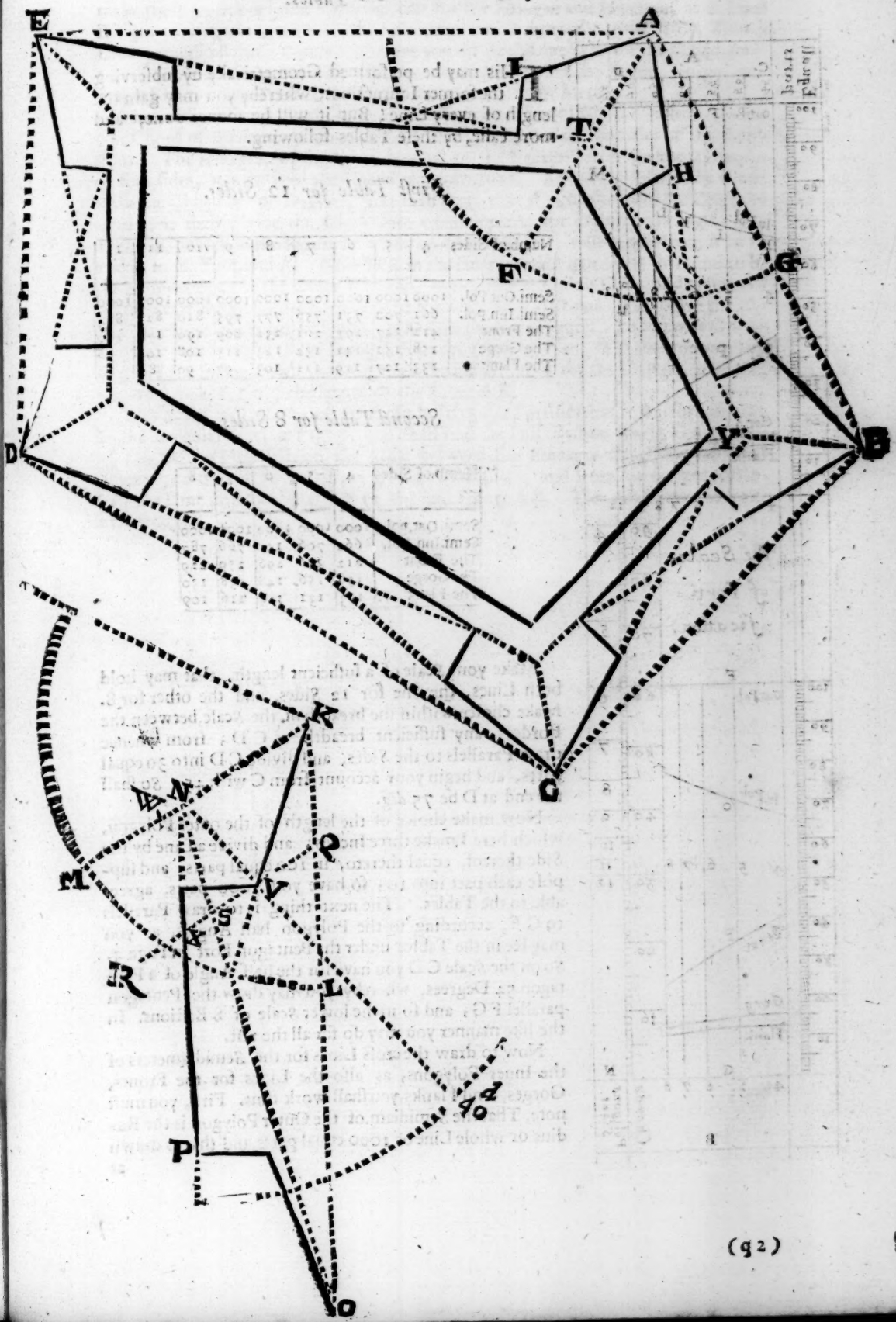
Now upon ſome ſpare Paper you ſhall make the half Polygon-Angle G A F, as you may ſee underneath this Figure, as L K M; Then make choice of the Capital Line, as before; let it be of any convenient length (larger than you think your Baſtion will be in the Figure) as underneath K N, and from N the Center of the Gorge draw a Parallel to K L, continued to O, as N P; and ſo proceeding as before, you ſhall find the Point of the ſecond Baſtion at O: So have you the Proportion of your Baſtions, whereby you may gain thoſe in the Figure.

Now to reduce it from the Baſtion Point at A, you muſt take A B the ſhorteſt ſide, and lay it from O unto Q; and from Q draw a Line parallel to the Capital Line K N continued, as Q R. Laſtly, drawing a Line from N to O, it ſhall cut Q R in the Point S; ſo is Q S the Length of the Capital Line ſought for, which muſt be laid down on the Figure from A unto T; ſo is T the Center of the Gorge. Then for the Front take K V, and lay it on the Capital Line from K to W; ſo a Ruler being laid from W to O, it ſhall cut the Line Q R in the Point at X; ſo is Q X the length of the Front, to be laid down in the Figure from A unto H and I. Thus ſhall you finiſh your Baſtion, when you have let fall your Flanks perpendicular on the ends of your Curtains, as you ſee. The like Method you are to obſerve for the other Baſtions.

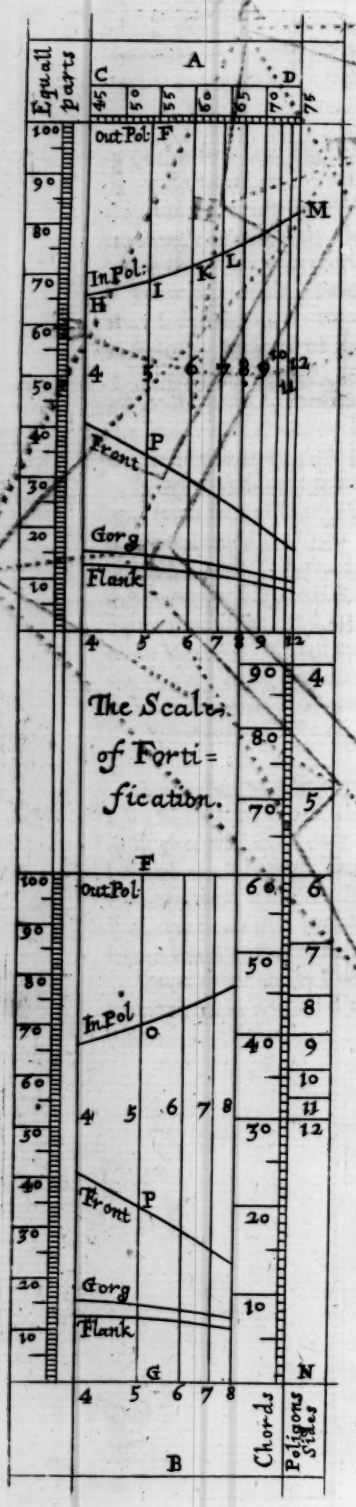
And when you have finiſhed your Fort, you muſt obſerve whether your Curtain Lines (that is, from the Centers of the Gorge) be parallel to the outward Sides A B, &c. which if they are not, you muſt correct them; and by your Judgment, by help of the Lines of Defence, you may, as you ſee occaſion widen the Necks of the Gorges, and alſo the Baſtion Angles; but not above 90 Degrees: And ſo let the Flankers be as near proportional as may be, which commonly the Gorge Line to the Flank bears proportion as 7 to 6.

Much more could I write of Irregular Fortification: But my purpoſe at this time is but to make a ſmall Treatiſe, or an Epitome thereof.

The ſeventh Figure, of an Irregular Fort, containing 5 *Baſtions; being the Platform of the Royal Fort ſometimes on St.* Michael's Hill, *on the North-Weſt ſide of the City of* Briſtol.



To make a Scale for Fortification by the Tables.



THis may be performed Geometrically by observing the former Instructions, whereby you may gain the length of every Line: But it will be sooner done, and more easie, by these Tables following.

First Table for 12 Sides.

Numb. of Sides	4	5	6	7	8	9	10	11	12
Semi. Out. Pol.	1000	1000	1000	1000	1000	1000	1000	1000	1000
Semi. Inn. Pol.	661	700	731	756	777	795	810	823	834
The Front	412	347	299	261	232	209	190	174	160
The Gorge	158	151	141	132	123	115	108	101	96
The Flank	133	127	119	111	103	97	90	85	80

Second Table for 8 Sides.

Numb. of Sides	4	5	6	7	8
Semi. Out. pol.	1000	1000	1000	1000	1000
Semi. Inn. Pol.	661	706	740	766	787
The Front	412	346	296	259	229
The Gorge	158	156	148	138	130
The Flank	133	131	124	116	109

Make your Scale of a sufficient length, that may hold both Lines, the one for 12 *Sides*, and the other for 8. Make choice within the breadth of the *Scale*, between the Borders, any sufficient breadth, as C D; from whence draw Parallels to the *Sides*, and divide C D into 30 equal parts, and begin your account from C with 45: So shall the end at D be 75 *deg.*

Now make choice of the length of the outer Polygon, which here I make three Inches; and divide a Line by the *Side* thereof, equal thereto, in 100 equal parts, and suppose each part into 10; so have you 1000 parts, agreeable to the Tables. The next thing is to draw Parallels to C E, according to the Polygon half Angles, as you may see in the Tables under the Pentagon Fort in Page 3. So on the *Scale* C D you have for the half Angle of a Pentagon 54 Degrees, whereby you may draw the Pentagon parallel F G; and so in the lower *Scale* of 8 Bastions. In the like manner you may do for all the rest.

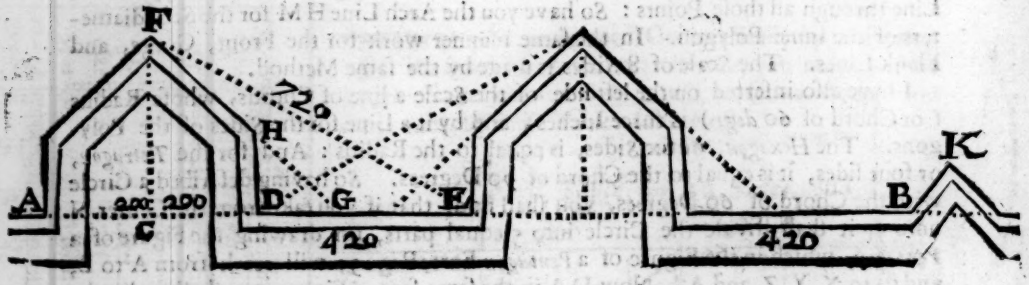
Now to draw the cross Lines for the *Semidiameters* of the Inner Polygons, as also the Lines for the Fronts, Gorges, and Flanks, you shall work thus. First, you must note, That the *Semidiam.* of the Outer Polygon is the Radius or whole Line of 1000 equal parts, and that is drawn at

at Right Angles at *F*: But for the *S*emidiameter of the Inner Polygon, look in the Table of 12 *S*ides in the ſecond Column under 4, you have *661*. Take that Number off your *S*cale of equal Parts, and lay it from from E to H: Then in the third Column under 5, you have 700 parts; lay the ſame down from G to I, and make there a prick or point: Do the like for the *Hexagon* and *Heptagon*, as at I and K; proceeding along with all the reſt, unto the *Dodecagon*. And laſtly, draw a Line through all thoſe Points: *S*o have you the Arch Line H M for the *S*emidiameters of the Inner Polygon. In the ſame manner work for the Front, Gorge, and Flank Lines. The *S*cale of 8 *S*ides is made by the ſame Method.

I have alſo inſerted on the left ſide of the *S*cale a line of Chords, whoſe Radius (or Chord of *60 deg.*) is three Inches; and by it a Line for the Sides of the Polygons. The *Hexagon*, or ſix *S*ides, is equal to the Radius: And for the *Tetragon*, or four ſides, it is equal to the Chord of 90 Degrees. *S*o having deſcribed a Circle with the Chord of 60 Degrees, you ſhall find, that if you take from the Center N. unto 5, it ſhall divide the Circle into 5 equal parts, for drawing the Figure of a *Pentagon*, which in the Figure of a *Pentagon* Fort, Page 3, will reach from A to B, and ſo to X, Y, Z, and A. Now D A in the ſame ſecond Figure you ſhall find to be the *S*emidiameter of the Outer Polygon, which in the *S*cale is G F; and taking G I off the *S*cale for 12 Baſtions, or G O on the *S*cale of 8 Baſtions, it will give the *S*emidiameter of the Inner Polygon, as D O in the ſame Figure. *S*o likewiſe G P on the *S*cale will be equal to the Front A K in the *Pentagon* Fort. The like you may underſtand for laying down the Gorge and the Flank. And for the Curtain, as before, you muſt make R *S* 1 ½ the length of the Front A K.

This *S*cale will alſo be of good uſe in Irregular Fortification. As for inſtance, In the Irregular Fort, in Page 9, you ſhall find the half Baſtion Angle G A F to be 58 Degrees, which falls on the *S*cale between the *Pentagon* and *Hexagon*, from whence you may draw a Baſtion on ſome ſpare place, and from thence proportionate the ſame unto the outer ſide of the ſaid Figure A B. The reſt I leave to your own practice.

How to Fortifie a long Curtain with Bulwarks, or a ſtraight Town Wall.



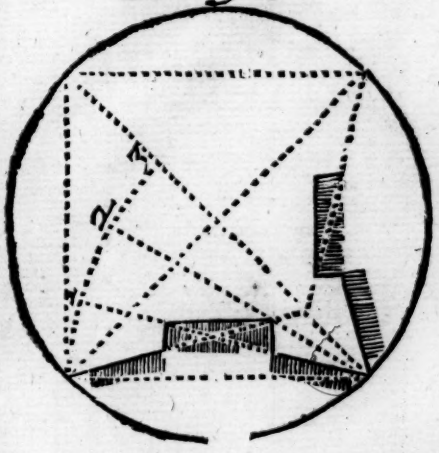
LEt the Curtain be A B. Firſt take 200 Foot from the *Scale* of Fortification, accounting 10 for 100; and lay the ſame from A unto C, and from C unto D: *So* ſhall A D be the breadth of the Neck of the Gorge: and upon the Point C erect a Perpendicular, as C F. Then take 420 Foot off your *Scale*, and lay the ſame from D to E, which ſhall be the length of the Curtain. Next you muſt take 720 Foot, and lay the ſame from E, to cut off the Capital Line at F; ſo ſhall E F be the longeſt Line of Defence, and C F the Capital Line; which Line C F muſt be laid down from C unto G: and draw G F for the ſhorteſt Line of Defence. Laſtly, upon D erect a Perpendicular, which will cut the ſame Line in H; ſo have you D H for the Flank, and H F the Front. Thus have you finiſhed half the Baſtion, from whence you may tranſport all the reſt of the Baſtions, were they ever ſo many.

Note, That theſe Baſtions muſt not exceed 720 Foot, that ſo it may not be without Musket-ſhot. But if you will defend the Front with Cannon, you may make the Line of Defence almoſt twice ſo much. The like for the Curtain, which may be 800 Foot; and in the middle of the Curtain you may make a *Spur*, or Point of a Baſtion, as at K, which will be neceſſary for Musket-ſhot, beſide the Cannon; of which in the Line drawn about the City of *Briſtol* I have ſeen many.

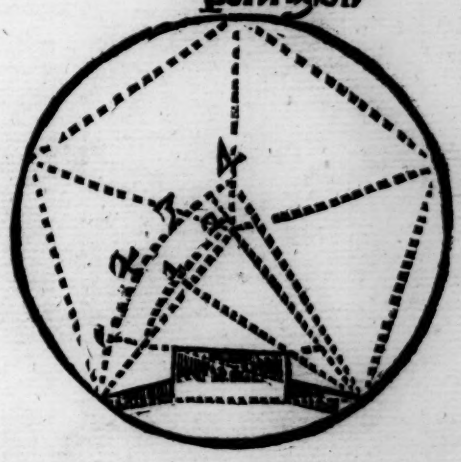
Theſe

These five following Pieces are taken out of Malthus, *The Proportions you may find by the Scale, and the Rules before shewed.*

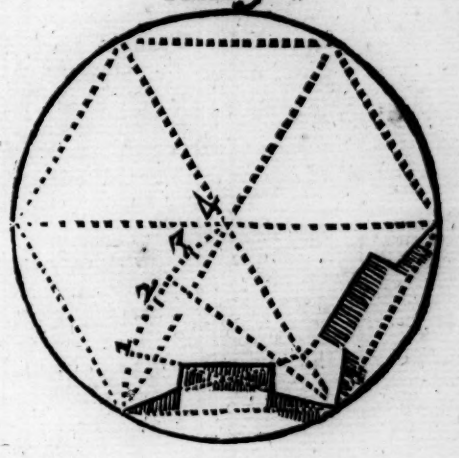
Tetragon



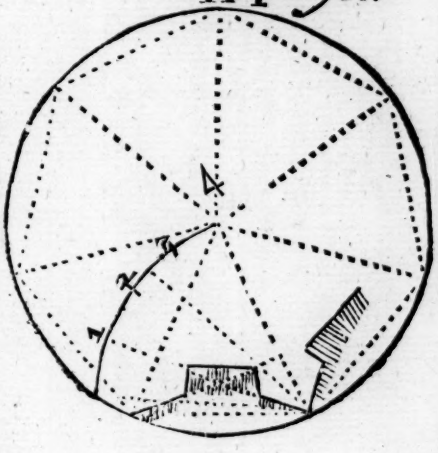
Pentagon



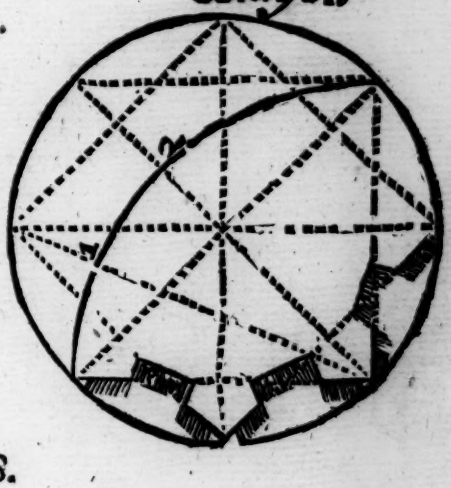
Hexagon



Heptagon



Octagon



FINIS.

